THE JOURNAL

OF THE

NATIONAL MALARIA SOCIETY

Volumes I and II

1942 and 1943

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VOLUME II 1943 Number 2

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P.O. Box 997, Tallahassee, Florida

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NOTICES

The Society plans to expand the Journal to a quarterly of approximately 50 pages per issue as soon as financial support and sufficient contributed material justify such action. At that time application will be made to the postal authorities for second class mail rates.

Material for Submission:

Contributed papers on any phase of malaria or related subjects should be submitted to the editor. If suitable papers contain tables, require illustrations, or will require more than six pages in the Journal for publication, acceptance will be contingent upon the willingness of the contributor to assume the extra cost entailed by special typesetting; manufacture of cuts or over-run, which amounts are to be paid directly to the printer. Orders for reprints should be placed with the printers, and are to be attached to the galley proof when it is returned to the editor.

Pertinent advertisements will be accepted from reputable firms. Correspondence in relation thereto should be addressed to the secretary-treasurer.

Subscriptions

The Journal will be sent at time of publication to all members of the National Malaria Society whose dues for the current year are paid. It will be supplied members then in arrears when they terminate the delinquency.

Subscriptions will be received from non-members and institutions at the rate of three dollars per annum from domestic subscribers, and three dollars and fifty cents from foreign subscribers. Subscriptions should be placed with the secretary-treasurer.

Revenue accruing to the Society from subscriptions will be wholly utilized for the support and enlargement of the Journal.

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MALARIA CONTROL IN THE WAR AREAS

By Louis L. Williams Jr., M. D.
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and
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In World War II, as in past conflicts, numerous major public health problems challenge the ingenuity and resourcefulness of the public health profession. Satisfactory prosecution of the war depends in no small measure on the effective handling of these hazards. Among the major public health problems, control of malaria has a prominent place.

Intensification of the national defense effort early in 1941 resulted in concentrations of military and industrial manpower in malarious areas. Cantonments and war plants mushroomed in many thinly populated areas in southern states thus creating a hazard where malaria previously had not been of major significance. Coincident with these increased problems, technical staffs of the State Health Departments were being depleted by transfer to the armed forces. Supplemental Federal aid was needed. During May and June of that year, the U. S. Public Health Service, in collaboration with the State Health Departments, initiated mosquito control measures in all critical national defense areas. Subsequent to July 1, 1941, with funds available to the Public Health Service for technical supervision, the program was continued, using WPA labor and materials.

Policies and Scope

Following the Declaration of War, funds were allocated to the Public Health Service for direct operation of anti-malarial measures in war areas. This activity, Malaria Control in War Areas, established headquarters in Atlanta, Georgia. Operations were initially restricted to the fifteen southeastern states and Puerto Rico, but subsequent modifications added three bordering states, the District of Columbia, and limited areas on the West Coast. Extension of the program to war areas in other states, Territories or Possessions, will be authorized if malaria jeopardizes the war effort.

The program, Malaria Control in War Areas, is a joint undertaking by the U. S. Public Health Service and the State Health Department. It is designed to control production of malaria mosquitoes and reduce malaria transmission in military extra-cantonment zones and essential war industrial areas. The malaria control bureaus of the State Health Departments operate the projects, utilizing

manpower and material resources of the Public Health Service. Policy direction is exercised and technical consultation is provided by the Headquarters office at Atlanta in collaboration with the Public Health Service Districts.

The Army and Navy operate mosquito suppressive measures within the boundaries of military reservations, relying on the Public Health Service to complement their program in contiguous civilian areas. These programs have added significance since the cycle of malaria prevalence probably reached its mean low point in 1941 and an upward trend in malaria incidence may occur in 1943.

The organization functions through close coordination of the medical, engineering and entomological services essential to an effective well-balanced malaria control program. Medical services provide interpretation of morbidity and mortality statistics on malaria, supervision of thick-film blood slide surveys to determine incidence of malaria in and near war areas, consultation on medical malaria problems, and direction of the education program. Engineering staffs are charged with the inauguration and operation of actual control activities, selection and allocation of equipment and supplies, preparation of engineering plans, and determination of control methods. Entomological services are maintained to determine the incidence and density of malaria vectors, particularly *A. quadrimaculatus*, locate breeding places and check effectiveness of control measures. Reports of the entomological service for the season just ending indicate that mosquito control was adequate. There were breaks in technique at about the rate of 8% a month but the field entomological check apparently caught these in time and control was reestablished. No malaria outbreaks were reported in any war area during the 1942 season.

Control of obnoxious mosquitoes under the present appropriation was specifically excluded. However, surveys of obnoxious mosquito problems are authorized as is control of *Aedes aegypti* mosquitoes where such measures have a definite war-connected significance.

At the request of the Navy Department, special surveys are being made to determine the cost of controlling obnoxious mosquitoes in the vicinity of a selected group of navy establishments. Preliminary findings indicate that a reasonable reduction of mosquito prevalence can be secured in seven of the eleven areas under survey. In some instances extensiveness of breeding marshes and infeasibility of drainage because of complicating factors such as tidal limitations will permit only limited control.

In June of this year the Public Health Service, following an

appeal by the Navy Department, inaugurated *Aedes aegypti* control measures at Key West, Florida as protection against dengue and yellow fever. Subsequent *Aedes aegypti* surveys at 13 southern ports of entry revealed indices ranging from 20 to 40. Heavy military traffic, particularly by air, from endemic areas increases the hazard of yellow fever introduction. Sporadic dengue fever might become epidemic in areas where war personnel are concentrated, if production of *Aedes aegypti* is permitted to continue unabated. Control operations have been extended to include the lower Rio Grande Valley and three other points in Texas; Charleston, South Carolina and supplementary assistance to the existing program at Miami, Florida. In addition to community education, inspections of premises to eliminate water-containing vessels of all types, supplemented by house spraying, if necessary, constitute the principal project activities.

For these three activities the total annual expenditure is approximately $8,000,000, of which $6,500,000 is provided by the Public Health Service. Personal service costs account for four-fifths of the funds expended and the remainder is distributed among equipment, supplies, rentals, travel and miscellaneous items. The large amount of administrative detail involved in the execution of a widely-scattered program of this magnitude has necessitated revision and simplification of many long-standing procedures.

Organization and Operation

A large percentage of the troops now in training are stationed in the malarious area of continental United States. Control measures cover extra-cantonment zones and the environs of earby towns regularly frequented by military personnel. Of equal importance are the vital war industrial areas located in the malaria belt. The program is now operating in 137 war areas located in 20 states, the District of Columbia, and Puerto Rico. Protection is provided to 570 war establishments, including army and navy reservations, air fields, vital war industries, and housing and recreational facilities for military and industrial personnel. To do the work, a total of about 3800 persons have been employed in the professional, subprofessional and labor classifications.

The main attack against malaria is through control of anopheline production by application of larvicides on all breeding places within flight range of the protected war establishment. The average larviciding unit consists of foreman, four oilers or dusters and a truck. Size of the control operation determines the number of larvicidal units. These units operate under an area supervisor who also

directs the mosquito inspectors and a small crew engaged in minor drainage and clearing. Activities incidental to the larvicidal program include minor drainage, brushing, clearing and removal of emergent vegetation and floatage from ponds and pooled streams. Major drainage work is prosecuted where a larvicidal program alone would be inadequate or too expensive. Inauguration of any major drainage project is contingent upon the availability of man power and equipment, which availability is considered in relation to other urgent war needs. Installation of permanent ditch lining is restricted to systems where the hydraulic gradient requires the use of lining, or where the ditches are an integral part of a drainage system of a permanent community and the necessary materials are furnished locally. Thirteen major drainage projects are now in operation. Other essential drainage will be prosecuted during the winter months.

For the five months ending November 1, approximately 1.5 million gallons of oil and over 100 tons of paris green were used to control *A. quadrimaculatus* production along about 31,000 miles (accumulative) of ditches and 80,000 acres (accumulative) of ponds and streams. Incidental clearing integrated with the larvicidal program, eliminated or reduced the need for larvicidal treatment in about 3000 miles of ditches and streams and 4000 acres of ponds. In addition, some 1900 miles of ditches and 3000 acres of ponds were cleaned debris and vegetation. Airplane dusting with paris green was used in covering about 4000 acres of breeding surface in two states.

Larvicide application is accomplished largely with hand sprayers and dusters. Over 2600 hand sprayers and more than 1000 hand dusters are in use. The magnitude of the problem at certain places has necessitated providing 37 power sprayers, 10 water-oil units, 30 power dusters, and 4 power mixers in order to obtain satisfactory control. For incidental clearing and drainage work shovels, picks, and cutting tools have been procured and distributed. Labor crews are mobilized by means of approximately 450 automotive vehicles.

The administrative organization for this extensive program was created on a stream-lined basis with direct contact between the Headquarters and the State offices. An administrative assistant and clerical aides are assigned to each state to expedite the flow of administrative matters. No clerical force is maintained at the projects. Time sheets, report and appointment forms are devised to permit the area supervisor and his technicians to maintain pencil records in duplicate with all typing and computations handled by the state and headquarters office. Engineers and entomologists are detailed to Public Health Service District Offices to assist the state malaria

control bureaus with the administrative and technical operation of the program.

Of the difficulties experienced in the operation of the program, the extreme paucity of trained technical personnel heads the list. This is especially true of engineers and entomologists. Within the past year about 60% of the trained or partially trained professional personnel was released to the armed forces. Recruitment of professional people replaced less than half of these losses. As a solution, subprofessional personnel beyond the limitation of Selective Service have been recruited, trained, and are being used as area supervisors in many states. Shortages of equipment and materials, priorities and rationing have further complicated the administration of the program. This has been partly offset by obtaining surplus property stores from curtailed governmental agencies and by establishing administrative machinery for direct handling of priorities and rationing.

In the present war, the degree of necessity and availability, man power and materials have replaced the dollar sign as the yardsticks for measuring justification for control projects and extent of operations. Concentrations and intermingling of war personnel obviously increase the potentiality of local outbreaks, especially if an upward trend in malaria incidence should materialize. As a compensating factor of safety, in the event of an outbreak, emergency supplementation of existing control work is planned. This includes pyrethrum spraying of interiors for destruction of roosting engorged *A. quadrimaculatus*. A mobile emergency unit with complete equipment and trained personnel has been assembled which can be dispatched upon a few hours' notice.

The program, Malaria Control in War Areas, is designed to make full and complete use of existing federal, state and local personnel and equipment resources. This requires coordination of the activities of all agencies. The complete cooperation of all State Health agencies brought the present success and its continuance assures the future.

"ANTI-MALARIA DITCHING BY DYNAMITE"

Nelson H. Rector
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The blasting of open earth ditches in wet or marshy ground has had long and successful practice at the hands of landowners, public health agencies, railroad companies, highway departments, contractors, and the U. S. Government. This nation is now engaged in an all-out war effort and it is, therefore, highly important that quick, direct, and economical methods of ditching be employed. Blasting is quick, when time is such an important factor. It requires little labor, when there is such a decided shortage of labor. It eliminates the use of equipment, when the materials required to produce equipment necessary to drainage work are so critically needed in the prosecution of the war effort.

Ditching with dynamite, where indicated, has numerous advantages which make it useful for war work. It is generally the least expensive method for ditching in soft mucky soils or through heavily wooded swamps. It permits ditching in ground too boggy to be shoveled or through ground so soft that there is no footing for a horse or support for wheels. (Although dynamite can be used for ditching in dry soils the unit cost is generally higher). To the malaria control engineer it is particularly valuable as it is the quickest known means of constructing an open earth ditch—after the right-of-way has been cut, a crew of three to ten men can blast 750 to 3000 feet of channel in one day. With all of its advantages, drainage by dynamite is unquestionably a specialized work and it is imperative that an experienced blaster supervise the operation.

The blasted ditch is produced by the explosion of a series of charges of dynamite placed in a single line of holes or in several lines of holes at given intervals and depths. By placing equal charges at the proper depth and correct spacings, and by detonating at the same time, it is possible to blast a ditch with regular width and depth. Following this principle, an experienced blaster can accurately construct a ditch of the desired dimensions. A blasted ditch is usually two to three times as wide as it is deep and the sides slope to the ratio of one to one (45 degrees).

If the charge is of the correct size and is placed properly, in most instances, the only work required after the blast is to remove a few drifts, and cut roots and logs remaining in the bottom and sides of the ditch.

The blasting method of constructing ditches may be employed for making almost any open ditch in any type of soil except

very thin muck, dry sand or gravel. About the smallest ditch that can be economically blasted is one two feet deep and three feet wide, and the largest, ten feet deep and thirty feet wide. The size or capacity of the ditch required, the grades, the depth and the line should be selected by a qualified engineer. In general, the line should be as straight as possible, but should remain on low ground. A fall varying from 0.1 to 0.5 feet per 100 feet has been found to be satisfactory.

There are two distinct methods of ditching with dynamite, the propagation and the electric. The propagation method can only be used in wet soils, while the electric can be used in either wet or dry soils. The explosives and blasting supplies needed and the methods of loading vary considerably in the two methods. In the propagation method, a line of holes is put down and loaded with 50 to 60% straight nitro-glycerin dynamite. Only one hole is primed and fired, either with an ordinary blasting cap and fuse or with an electric blasting cap. Since accidents have happened by the use of fuses, this method has been largely discontinued and instead the electric blasting machine is used for the detonation of shots. If the charge fails to explode, the machine can be disconnected and no danger results when steps are taken to determine why the explosion did not occur as planned. The shock from the explosion of the primed cartridge is sufficient to detonate the others. Frequently, one-half mile of ditch is shot at one time.

In the electric method, each hole is primed with an electric blasting cap, connected in a circuit, and fired with an electric blasting machine of sufficient capacity.

Before blasting the ditch a test shot of eight to ten holes should be made to determine the size of charge and the proper method of loading. The type of soil, moisture content, temperature, the kind of trees, and other factors must be considered as the success of the blasting operation depends largely on the results of these test shots. If the loading is satisfactory, the soil will be lifted 200 feet in the air and scattered over the adjoining territory for 150 feet on each side of the ditch, leaving a good clean ditch. If these objectives are not obtained different loadings must be used. In swamps, for example, the ditch is usually two to three feet deeper than the depth of charge. In different soils it is sometimes necessary to load to the proposed grade of the ditch. An experienced blaster can estimate accurately the amount of dynamite and the depth of charge required for specific soil conditions. If a test shot demonstrates that the resulting ditch is larger than needed, the distance between holes may be increased, but should seldom be greater than twenty-four inches.

After the engineer has determined that sufficient fall is available and has staked the center line of the ditch, a right-of-way, varying from ten feet to fifteen feet wider than the ditch, is cleared. All standing timber and logs must be removed, although it is not necessary to remove stumps. The reason that logs are removed is because they generally fall back in the ditch, and hence, can be carried off the right-of-way much easier before the ditch is blown. When the ditch is located in soil covered with a heavy sod, it is advisable to cut the sod on both sides of the ditch with a spade or plow before the blast.

In soft, swampy soils, the bore holes can be made with a round stick marked off in feet. If many roots are encountered, it will be advisable to make a punch bar of one and one-quarter inch galvanized pipe with a sharpened point and a cross bar. Two men using this bar can punch holes very quickly on the center line to the proper depth. Small ditches (for instance about 2 feet deep and 4 feet wide) in soils containing few roots can be constructed with half cartridge charges. A cartridge or stick of dynamite weighs ½ pound. When using small loads, the space between holes can seldom exceed 18" to 20". Larger ditches can be dug by using one, two, or more cartridges per hole, and a second or third row of holes may be put down four or five feet from the original line and loaded in the same manner. When two or three holes are used, it will be necessary to prime the center hole in each line with an electric blasting cap and connect them in series, or to put one or two extra charges between the rows to insure simultaneous detonation of all of the charges. When large stumps lie on the right-of-way, it is necessary to load them separately and connect these charges with the center line in order to insure propagation of these charges. Considerable judgment is necessary for the proper loading of large stumps.

If sections of the ditch are in relatively dry soil, the holes should be filled with water.

A good system to follow when blasting large and long ditches is to fire the charges at noon and in the afternoon after the men quit work. This system eliminates loss of time and increases the safety of the operation. Before firing, all tools and blasting supplies should be removed to a safe distance.

It is a good practice to increase the estimate of dynamite needed by from five to ten percent to take care of a few stumps and extra loadings. If large stumps are thick on the right-of-way, a separate estimate for blowing stumps should be included.

When the propagation method is used, a common practice is to place the primed cartridge in the center of the charge, however,

it can be shot from the end. If a blasting machine is used, the lead wire to the primed cartridge must be at least 500 feet long.

Dynamite may be used to advantage to clean out old ditches, but it is not advisable to use this method if the top width is less than twice the depth. Care must be exercised in placing the charge to prevent the force of the explosion from caving in the original sides and filling up the ditch. As it costs money to move water, it is not considered feasible to clean out ditches that contain more than two feet of water.

Under ordinary conditions, approximately one pound of dynamite is required to move one cubic yard of soft mucky material. For example, if it were desired to construct a ditch having a three foot bottom, a depth of 3.0 feet, and a top width of 9.0 feet, through mucky soil with few stumps, one cartridge (½ pound) placed in holes eighteen inches apart will give the desired results. However, this amount should be increased if the soil is full of roots, if the ditch exceeds three feet in depth, or if unusual soil conditions prevail.

Sometimes it is necessary to construct an outlet ditch across bends in an old natural channel in order to increase the flow and thereby effect better drainage. These cut-offs can be made very economically if a relatively large amount of water flows through the ditch. This method consists of the construction of a small cut-off ditch with dynamite, and then depending on the rapid motion of the water to scour and erode the ditch to the proper size. Instances have been reported where the size of ditches has been increased three or four times by the running water.

If this method is used, a dam must be built in the upper end of each cut-off in order to prevent the water from following its natural course, and steps must also be taken to fill the old run to a grade so that no water will remain to breed mosquitoes after the ditch has been constructed.

Vertical drainage can be used to advantage when a pond is underlaid by a strata of hardpan on top of a water bearing strata. This method is accomplished by drilling a hole almost through the hardpan and loading it with a sufficient amount of twenty or forty percent ammonia dynamite distributed along the bore hole to shatter the entire layer of hardpan. If the hardpan is of a gritty nature, no further treatment is necessary, but when it is slimy or silty, the loading must be heavy enough to create a rough well or crater. This crater is then filled with any sort of available rubbish such as brush or boulders and stump fragments. This debris prevents clogging of the drain.

Vertical drainage is practical for draining clay pits, road and

railroad borrow pits, and small isolated ponds where horizontal drainage would be extremely costly. It must be kept in mind that this method should never be used unless prior approval for the project has been obtained from the State Sanitary Engineer or the State Board of Health, as the ground water might become contaminated.

Dynamite has been used this season for ditching and draining two large *Anopheles* breeding areas which were located in proximity to war establishments. The cost of partial control of mosquito production in one of these areas for one season by airplane dusting (which would have been the only possible method) would have greatly exceeded the total cost of the dynamite work. On the other project the estimated cost of drainage by machinery was $80,000.00, while the outlet ditch was constructed with dynamite for approximately $5000.00. In both instances, it would have been impossible to complete the projects with machinery before the end of the mosquito breeding season. If control by larvicides had been feasible, the recurrent cost each year would have been high; while in contrast the maintenance cost of the dynamite ditch is very low.

Some idea of the speed with which dynamite work can be done can be gained from the fact that on one of these projects, a large outlet ditch approximately two miles long was practically finished in two weeks, draining 90% of a 300 acre swamp. The excavation amounting to 16,500 cubic yards, was done at an average cost of $0.29 per cubic yard.

While it is true that this method is not dangerous if handled carefully by experienced employees, it is equally true that it is very dangerous if employed by inexperienced or careless workers. It is recommended that the fuse method never be used for the detonation of dynamite, and that the electrical blasting machine used to detonate the charges never be allowed to lay around carelessly on the right-of-way. This machine should only be entrusted to the most reliable, careful man on the project who will hold it until the ditch is properly loaded and is ready for detonation. We believe that dynamiting is a very valuable method for constructing ditches, where its use is indicated.

Discussion of Paper by Nelson H. Rector Entitled "Anti-Malaria Ditching by Dynamite by

R. E. Dorer

It is my opinion that Mr. Rector has covered the subject of dynamite ditching so completely and factually that there is little left for me to say.

In all of the major points I concur with him. There are a

few minor points, however, that I do not fully agree with, and there are a few other points which perhaps I can elaborate on.

Mr. Rector recommends that a test shot of eight to ten holes should be made to determine the size of the charge and the proper method of loading. I do not believe that this is sufficient for a test shot. My experience would lead me to recommend that at least 100 feet of ditch be blown as a test. A dynamite ditch is influenced at the ends by either a barricade of earth or no resistance at all. In order to get a true picture of how the charge is going to work it is necessary to blow enough ditch to get away from this influence. This is especially true in large ditches. It has been my experience that a dynamite ditch will be very uniform throughout its length in cross section, all things being equal, but that quite often a bump or a hole will be left where one shot was completed and another started.

In connection with loading we have found that sash cord stretched on line and knotted at the proper intervals is a very good way to place the dynamite on line and at the proper spacing. It is necessary in order to produce a uniform ditch to place all the dynamite at a uniform predetermined depth.

Sometimes the soil to be blown is so mushy the bore holes will close up before the dynamite can be put in them. In such cases it is necessary to have a special bar made. This consists of a core bar. Around the core is made a tube with a cross bar at the top. A pin is inserted at the top through both the tube and the core. The entire ensemble is thrust into the muck to the proper depth. The pin is removed and then the core is withdrawn. The sticks of dynamite are then dropped inside the tube and the tube is then removed.

Mr. Rector refers to the use of dynamite for vertical drainage. With regard to this it might be advisable to find out if such a plan will work by a test boring before any great amount of blowing is undertaken. I make this point because at one location in Virginia several years ago we were contemplating vertical drainage. As a test we sank a well point expecting to see the water in the pond run down the pipe. It was confusing, to say the least, to note water coming up the pipe instead, and further work along this line had to be ruled out.

Dynamite when treated with due respect is not dangerous. This is the all important factor and can not be emphasized too much in the minds of the men working with it. There are general rules for safety which always apply. However, it is necessary on most jobs, especially during war emergency, to make special rules.

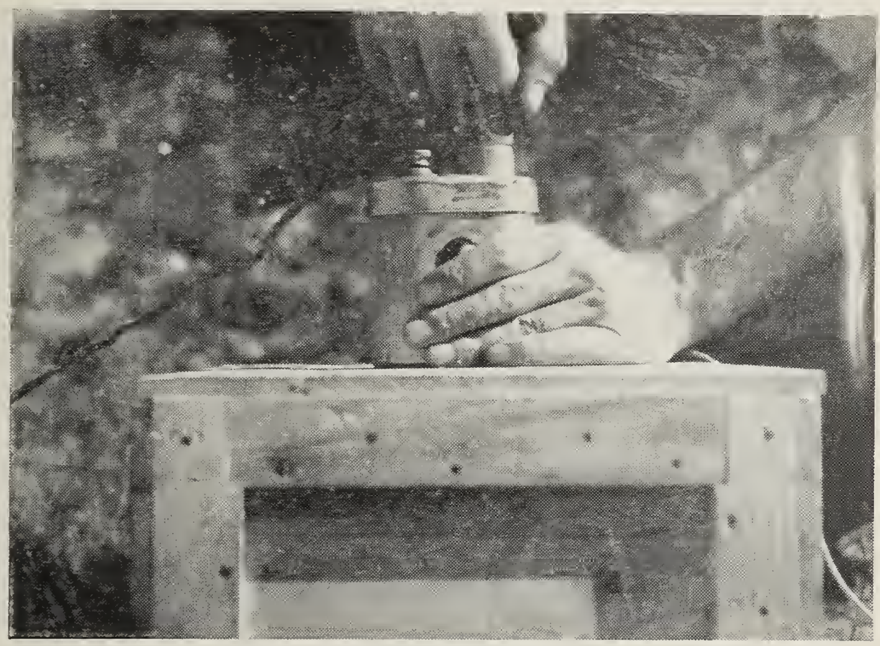
The first general rule is, "When in doubt don't take a chance."

An Old Ditch to be Re-Channeled by Dynamite

Locating the Loading Holes

Putting in loading Holes with a Punch Bar

Placing an Electric Cap in a Stick of Dynamite



Pocket Size Detonator with Safety Handle

The Blast

The Finished Ditch at the Same Location as Shown in Figure 2

It is the unusual that causes accidents. The dynamite manufacturers recommend a circuit tester (galvanometer) on the job to test the circuit before firing.

This is a great aid in locating broken wires. Men should be sent through the woods calling and sentries should be placed prior to each shot. The man who fires the shot should get an O. K. from all men before he connects up and fires. The dynamite should be loaded first and then the lead wire strung to a safe place for firing. I recommend that electric caps be placed in the windward end of the loading and desire 500 feet of lead wire. The electric exploders should be placed last. One man should be designated to always "blow," and he should have the detonator with him at all times. I recommend the small pocket size detonator with the removable special handle as the most foolproof instrument for firing.

The war has made it necessary to account very carefully for every stick. Dynamite brought to the job but not loaded and fired should be returned to the magazine each night. It is essential that a capable, well trusted man be charged with this responsibility.

It is necessary for the dynamiter to look up as well as around. On the Dam Neck job this summer our man loaded an exceptionally heavy load under a high tension line. If the shot had been blown the chances are the line would have been blown out, and it may have electrocuted someone in the bargain. I can speak with authority when I say, "Look up, young man, look up".

At a certain project in Virginia it was common practice for Navy planes to fly very low during maneuvers. One plane flew very close when a shot was fired and was observed to wobble and wave. Luckily he happened to be far enough away so that no harm was done. This incident, however, made it necessary to make a job rule. The Navy was contacted and informed that we would fire each day at 3:00. Their aviators were notified and no further near accidents occurred.

In closing I would like to suggest that Mr. Rector's paper be printed or mimeographed so that anyone doing dynamite ditching or contemplating same will have it for ready reference.

DYNAMITE DITCHING

John E. Taylor of Little Rock, Arkansas

Mr. Rector has covered the general points of dynamite ditching but I wish to discuss more in detail some of the difficulties encountered on projects which have just been completed in our State.

The type of soil has a great deal to do with the success of the

operations. It happens quite often that where drainage is most needed, the soil is heavy gumbo which, when wet, clings together like rubber, and when thoroughly dry, gets as hard as rock. On the first project undertaken, it was necessary to dynamite a long outlet ditch to drain a large swamp of approximately 300 acres. At the time the survey was made, the location through which the outlet ditch was to be run was covered with several inches of water and was ideal for shooting; but of course, before blasting operations could be undertaken, it was necessary to cut the right-of-way. The clearing of this right-of-way required about two weeks and by the time everything was in readiness for dynamiting, the ground had dried thoroughly and was so hard that it was almost impossible to push a punch bar through in order to make a hole for loading the dynamite.

In order to facilitate this punching operation, we had a crew carry containers of water and as the punch was worked up and down, a small quantity of water was added which made it easier to punch the hole. We were getting heavy *quad.* breeding in the areas we were attempting to drain. Several thousand persons were working at the Arsenal within one-half mile. We could not wait for rain to soften the ground or cover it with water, and since we had planned on using propagation method, rather than separate caps in each charge, it was necessary that the soil be wet in order to get propagation. After the dynamite was loaded in holes, we had a crew of laborers fill each hole with water. This was allowed to seep into the ground, wetting the area around the dynamite for several inches. After this had soaked in thoroughly, the same operation was repeated. After the ground had been wet thoroughly three times, we were ready to shoot. The ground had become wet enough that the dynamite would propagate and we made a very successful shot without any break in the dynamite charge.

It is very desirable to shoot as much ditch as possible at one shot for the reason it is necessary to load rather heavily the point where the ditch and the loaded section join; this is to prevent a barrier being left in the ditch. Considerable time is lost in moving men and material a safe distance from the blast, and the fewer times this happens during operations, the less total time lost.

At another time, the opposite of the dryness previously encountered, was found in attempting to dynamite an outlet for an old lake. This lake had been silting for many years and the soil was so unstable that it was possible to shore an 8-foot range pole completely out of sight. The ground on top was firm enough to walk on but would not hold a drag line, even on mats. We desired a ditch approximately 25 feet wide and about 3 feet deep. A test shot was

made in a section 25 feet long where the dynamite was spaced in two rows 3 feet each side of the center line. The dynamite was loaded ½ lb. stick 12 inches on centers. The charge was then set off, but the result of this test was a general churning of the ground in a section approximately 25 feet wide and 12 inches to 14 inches deep.

This test shot showed that dynamite was unsuitable for this type soil.

Another test was made, this time placing two sticks of dynamite 24 inches on centers down the center line of the ditch, but about the same type of ditch was obtained as the first shot.

A third test was then made, this time one stick of dynamite was placed 12 inches on center with the top of the stick level with the surface of the ground. We were able to get a ditch 9 feet wide and 2½ feet deep from this charge. Since we were unable to get a large ditch in this soil, we used the last test shot, placing the sticks of dynamite 12 inches on centers and level with the top of the ground.

A very successful use of dynamite was found in cleaning an old drainage ditch in which the soil was principally a sandy clay. We desired a ditch approximately 9 feet wide and 3 feet deep. The dynamite was placed 12 inches on centers down the center line and about 16 inches under the ground. We obtained a most successful ditch in this type of soil and the ditch came out approximately 10 feet wide and 3 feet deep.

In giving consideration to the economic justification of the dynamite project, I have taken the cost of larvicidal work for the past season and find the average cost in the State is approximately $5.00 per acre treated. This is broken down into six man hours at 55c and an average of 22 gallons of Diesel fuel oil at 8c. When you consider this operation must be carried on approximately twenty-four times during the season, you have a cost of $120.00 per acre of water surface treated.

We found that by the use of dynamite, we could clear drainage ditches of considerable amount of water by shooting out the barriers and high places that had accumulated in the ditches. Most of our drainage ditches have a water surface of approximately 20 feet in width, which is approximately an acre per half mile. We were able to ditch out many of these areas with the use of dynamite at a cost of 9c per lineal foot or $450.00 per mile.

In justifying the cost for a large project, it was found that the only method of treatment for a swamp consisting of approximately

300 acres was by airplane dusting. The best cost we could figure out was $1.00 per acre per application, which was about $300.00 per application. This, over a season of twenty-four applications was approximately $7,000. The entire area was drained dry and with a very small amount of work, can be permanently controlled. The total cost of the project was $6,400.00.

Expert consultant service is available through most of the large dynamite companies and I think this service should be utilized to the fullest extent as these consultants are familiar with the latest and most improved methods of the use of dynamite and can tell readily whether dynamiting is the proper method. In certain instances, where the quantity of dynamite is sufficient to justify, technical supervision will be furnished by the dynamite companies to supervise actual shooting.

I much prefer drainage over larvicidal measures in malaria control work where possible, and have found that dynamite is one of the quickest and also the most economical method of obtaining the desired drainage.

"ENTOMOLOGICAL SERVICES IN THE REGULATION OF THE LARVICIDE PROGRAM"

By G. H. Bradley
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U. S. Department of Agriculture
(On duty with U. S. Public Health Service—Malaria Control in War Areas)
And
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Federal Security Agency

The habits of each of our malaria carrying mosquitoes have become rather well known through investigations made during the past several years and therefore, when the Malaria Control in War Areas Program was undertaken, information was available on which to base selective measures designed to control malaria by controlling only the important transmitting anophelines. These are, in the Eastern United States, *Anopheles quadrimaculatus;* in the lower Rio Grande Valley, *A. quadrimaculatus* and *A. albimanus;* and in the Far West, *A. (maculipennis) freeborni.* Control of the first of these, *A. quadrimaculatus,* constitutes the main problem in the United States, and this discussion is limited to that species.

Of the habits of *quadrimaculatus,* probably none is more important in enabling an economical control program to be operated than its short flight range. Because of this habit, effective control of adults in a given area usually can be obtained by controlling breeding within a radius of approximately one mile and, under the present program, control work has been confined to the area within such limits of the war establishments being protected. Experience during the past season has given added evidence as to the soundness of this procedure. In a few cases where intense breeding was occurring just beyond the one mile limit, it was found advisable to extend operations, but in most instances where trouble was experienced, careful resurveys of the mile-wide zone located the source of the mosquitoes either in new breeding areas or in regularly treated areas where the larviciding work was ineffective.

It is well known that *quadrimaculatus* adults seek shelter during the day in secluded situations which are dark and out of draughts. By periodically counting the number of resting adults in such places as stables, privies, tree hollows, underneath houses and the like, an index to fluctuations in adult abundance in any area can be obtained by which the effectiveness of control work can be gauged. To obtain such an index a series of adult collection stations was established in each control area and the number of ano-

phelines in each station counted each week. These stations were classified in each area as to location. Those within the protected war establishment or within ¼ mile thereof were designated "A" stations, those ¼ to ½ mile, ½ to ¾ mile, ¾ to 1 mile and those over 1 mile away were designated B, C, D, and E stations, respectively. Although we were chiefly concerned with maintaining low mosquito populations within the war establishments, information on densities at distances from the protected zone was desirable as a study of these densities gave assistance in locating sources of mosquitoes.

It is known that all bodies of waters are not suitable for *quadrimaculatus* breeding, as this mosquito is essentially a "pond breeder", being found chiefly in rather quiet waters which range from neutral to alkaline in reaction. However, no attempt was made to classify the waters of the control areas by environmental criteria. Classification was made on the basis of whether or not the waters actually were breeding *quadrimaculatus* as determined by identifying larvae collected from each location. It was the intention when planning the larvicide program to limit control measures to those places which actually were breeding *quadrimaculatus*. Although this policy was not strictly adhered to because of the scarcity of trained personnel, the work was limited to *Anopheles* breeding places.

The entomological work was organized under the direction of the Medical Officer in Charge, with a chief entomologist responsible for setting up the procedures to be followed in the various states, for selecting and training the professional personnel, and for the general over-all supervision of the Entomological program. In this work, the chief entomologist was assisted by regional entomologists who periodically visited the various projects in the states in their assigned regions where they aided in the organization of the program and gave advice and assistance in working out unusual problems.

The work in each state was supervised by a state entomologist who was directly responsible to the State MCWA Director for the adequate organization and functioning of the entomological service in his state. His duties included the training and supervision of area inspectors; the inspection of areas to see that collecting stations were sufficient and of suitable type; the identification of anophelines; the proper preparation and transmittal of summarized reports to the Headquarters office; and most important of all, the explanation and interpretation of entomological data to the control supervisor.

The routine survey and inspection work in each area was done by the inspectors, one or more being assigned to each area. His initial duties were:

(1) To make surveys of the area to find all probable anopheline breeding places, and locate these on sketch maps, giving each breeding place an individual number or other designation.

(2) To locate and designate suitable adult resting places or to establish artificial resting places if necessary for use in obtaining an adult density index.

(3) To arrange for the operation of one or more light traps for the purpose of obtaining adult density records for comparison with those obtained from natural resting places.

After the above set-up was established, the inspector was charged with making inspections of his area, planning his routine so that the whole area could be covered once each week. At each larval station, he determined and recorded on his report form whether or not there was anopheline breeding present, and if so, the extent of such breeding, and the size and abundance of the larvae found. Samples of the larvae found were collected periodically for identification.

The adult index stations also were inspected once each week, the mosquitoes either being collected, taken to the laboratory, identified and counted there, or merely counted in place, if the inspector was sufficiently trained to determine the species.

The reports of the inspector were presented to the area engineer each day. The larval reports showed the efficiency of the larvicide work; the need for initiating work in regularly observed places where work had not previously been necessary; and also showed those places where, due to a continued lack of breeding, no larviciding was necessary.

The reports on adult abundance kept the engineer informed on the trend of the adult *quadrimaculatus* population in his area and it was his duty to give immediate attention when increases occurred, as adult mosquito densities inside or adjacent to the war establishments were the criteria by which the effectiveness of the whole larvicidal control program was judged.

The inspector's duties were not only to report accurately on his regular station observations each week but to become so familiar with his whole area that when any increases in adult *quadrimaculatus* abundance occurred he could quickly discover the source. All of the inspectors were not of a research type, of course, but in baffling cases they could always call on the state or regional entomologist for assistance with their problems.

State Louisiana LARVAL MOSQUITO COLLECTION—*Field Record*
Area Monroe Date July 7, 1942 Collector Jackson Identifier Smith
Notes Airfield

Station Number	Location or Remarks	Last Date Larvicide Applied	No. Dips	Anopheles Total	Small	Large	Pupae	quad.	cruc.	punc	Others Total	Identified Species
1-A		7/4	10	40	30	5	5				25	P. columbiae
2-A		7/4	30	0							0	
3-C		7/4	30	4	4						8	"
4-B		6/13	30	20	20						10	"
5-D	Dry	7/4	0									
6-A		6/20	10	25	15	5	5				25	C. quinquefasciatus
7a-A		7/4	30	25	10	3					8	C. salinarius
7b-B		7/3	30	0							6	"
8-B	Dry	-	0									
9-C		7/3	30	0							3	Culex sp.
10-C		7/3	30	15	15						5	"
11-E		-	10	50	25	15	10				15	"

MCWA-101 U. S. P. H. S. Malaria Control in War Areas FORM M-1

Figure 1

In figure 1 is shown a copy of the report form used by the inspector in reporting his examinations of *Anopheles* breeding places. The numbers in the left column are those which designate

State Louisiana ADULT MOSQUITO COLLECTIONS—*Field Record*
Area Monroe Date 7-10-42 Collector Jackson Identifier Jackson
Notes Airfield

Station Number	Location or Remarks	Anopheles quad. M	quad. F	cruc. M	cruc. F	punct. M	punct. F	M	F	Total M	Total F	Culicines M	Culicines F	Species
1-A	NRP		0				1				1		3	P. columbiae, A. vexans
2-A	NRP		1								1		0	
3-B	NRP		3				7				10		5	P. columbiae, A. vexans, C. quinque.
4-A	NRP		0								0			
5-C	NRP		8			2	18			2	26		10	P. columbiae, A. vexans
6-A	ARP		1								1		0	
7-B	NRP		5								5		2	P. columbiae
8-C	NRP		10				8				18	1	10	P. columbiae, A. vexans, C. quinque.
9-D	NRP		20								20		8	Culex sp.
10-E	NRP	8	45							8	45	2	15	P. columbiae
A-A	LT		1								1		10	A. vexans

MCWA-102 U. S. P. H. S. Malaria Control in War Areas FORM M-2

Figure 2

the individual breeding places. The letters following the station number indicate the distance of the station from the protected area as follows: A, within ¼ mile; B, ¼-½ mile; C, ½-¾ mile; D, ¾ to 1 mile; E, over 1 mile. The second column is used for any specific

information about a station showing a condition other than normal, such as "dry", "flooded", etc. Station descriptions are omitted on each report as a list of these is kept on file for reference. The third column shows the last date when larvicide was applied in each place. As the inspections were made 2 to 3 days after treatment, small larvae usually could be found at each active breeding place. If large larvae or pupae were found, the larvicide work was not altogether effective. The results of the larval collections were recorded in the remaining columns of the form. It was the inspector's duty to cover adequately the area being examined, multiples of ten dips were used in order to allow uniform summarization of records.

In the particular report illustrated, the record on the first line shows that Station 1 is within a quarter-mile of the protected area, that anopheline larvae in numbers were found, some of which were large, and that pupae also were present. As it is shown that a larvicide treatment was made three days previous to the inspection, such work was ineffective. A retreatment of this place should, therefore, be made immediately. Since Stations 2, 7b, and 9 show no anopheline breeding, and the inspection was made sufficiently long after larviciding to show small larvae if the locations were actively breeding, these need not be placed on the larviciding schedule until subsequent inspections indicate breeding. At Stations 3, 4, and 10, anopheline larvae were found but since none was large, successful larvicide work is indicated and continued control work is necessary. The record for Station 6 shows that for some reason this location was not treated on schedule and that it was actively breeding *Anopheles*. This might be due to an erroneous report made by the inspector the preceding week or to neglect by the larvicide crew. An inspection of the preceding week's reports would decide which was at fault. Station 11, being outside of the control area, is observed only as a general check on breeding conditions in the adjacent uncontrolled area.

By following these reports, a considerable saving can be made in both larvicides and expense of application. Of greater importance, however, is that by this periodic inspection, any important oversights or inefficiencies in the control work can be corrected before the situation gets out of hand.

Adult densities in the area were reported by the inspector on the form illustrated by figure 2. As in the larval report, each observation station is numbered and the number is shown in the first column, together with a letter to designate its position in relation to the protected war activity as previously described.

The letters in the second column refer to the type of the station: "NRP" indicates that the station is a natural resting place. Barns, stables, privies, underneath bridges, under houses, etc., were the types most frequently used. When a good natural resting location could not be found, boxes or kegs, suitably located, were used for this purpose and were designated as "ARP", or artificial resting places. Light trap collections were designated as "LT".

Upon receiving a report of adult densities similar to that illus-

MCWA No. 42

U. S. PUBLIC HEALTH SERVICE MALARIA CONTROL IN WAR AREAS

Headquarters Office, 605 Volunteer Bldg., Atlanta, Ga.

SUMMARY OF WEEKLY ADULT A. QUADRIMACULATUS REPORTS

STATE A AREA B ZONE C

Week Ending	Maximum Light Trap Collection						Natural and Artificial Resting Stations											
	No. NE A		No.		No.		No. 1 A Chicken House		No. 3 A Shed		No. 4 A Chicken House		No. 2 B Stable		No. 5 B Stable		No. 6 C Stable	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
May 30								27		9	1	7	1	7		8		4
June 6								3		5		4		9		0		3
13								3		3		0	2	16		2		5
20							1	5		3		0		11		13		6
27		2					1	12	1	4		5		7		13		2
July 4		2					1	5		1		0		9		4		5
11		1					3	3		1		0		7		5		2
18		2						3		5		6		4	1	4		2
25		3						0		1		2		0		0		0
Aug 1		0						0		0		1		3		4	1	5
8		1						2		1		2	1	2		2		0
15		3						1		0		1		3		0		0
22		1						2		0		0		5		1		3
29		1						3	1	0		0		1		0		2
Sept 5		1						0		1		0	1	3	1	4		1
12		2						0		0		0		2		3		0
19		3						4		0		1		2		3		0
26		1						0		0		0		1		3		0

Figure 3

trated, the engineer should interpret it to mean that adequate control is being maintained. The adult stations within a quarter-mile of the protected area (stations 1, 2, 4, 6) have very few adults, while the increasing densities in stations at distances (B, C, D, E) from the protected zone indicate what conditions might be if no control program was in operation. When high *quadrimaculatus* counts occur in "A" stations, the larval report should show whether it is due to inefficient larvicide work or to undiscovered breeding places.

After clearing the Area Engineer's office, copies of the inspector's daily report forms, together with any collections of larvae and adults needing identification, were sent to the State MCWA headquarters. Here the state entomologist identified the specimens, noted the determinations and prepared summaries on special forms, one copy of which was returned to the area office, while others were transmitted to the District Office of the Public Health Service, and to the MCWA Headquarters Office in Atlanta.

A special form with separate columns for each common mosquito species was used for reporting light trap collections. Because of the large amount of routine work involved this summary was not submitted regularly. As was shown on the adult field record form, however, the anophelines from two light trap catches were reported each week on the field record forms in the same manner as the resting station collections. Complete identification and recording of mosquitoes other than anophelines was postponed until the winter months.

These record forms are an outgrowth of conferences on procedures attended by officials of the 4th Service Command, U. S. A., the Bureau of Entomology and Plant Quarantine, the U. S. Public Health Service, and the Georgia State Board of Health. They are based on forms used by established control and research organizations which were studied before decisions were made as to the type best suited for the work being undertaken. As finally prepared, the forms were adopted by both the 4th Service Command, U. S. A., and the Public Health Service in order to have uniformity in operating methods, schedules, and records, the object being to have one coordinated program in each specific war area.

Upon being received in the Headquarters Office, the reports are studied and further summarized and the pertinent data made available to the several regional and district engineers and entomologists. A summary form which was devised to keep the various offices informed on the conditions in each area, is that illustrated in figure 3. This selective summary shows at a glance the trends of

quadrimaculatus abundance in the observation stations within or adjacent to a protected war activity. By the use of this form, sudden rises or continued high densities in any area are immediately apparent and investigations by supervisors can be quickly arranged.

These entomological procedures, established for the purpose of guiding the control work, have been of great value in increasing the efficiency of the Malaria Control in War Areas Program. The system has not worked perfectly in all cases. As the season progressed, however, their value became increasingly evident to those charged with prosecuting the control work and it is believed that there is little question but that the inspection work has been fully justified.

"ENTOMOLOGICAL SERVICES IN THE REGULATION OF THE LARVICIDE PROGRAM"

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The paper just read is an excellent review of a difficult achievement: the institution of standard entomological procedures for guiding a control program around the hundreds of war areas scattered throughout the malarious sections of the United States.

It occurs to me, using a term suited to our war time activity, the entomologists form sort of an "intelligence unit" for the Malaria Control in War Areas Program. Theirs is the task of continuously gathering data on the prevalence of adult *Anopheles quadrimaculatus* in and around the control areas, and of presenting such to the engineers so that the control measures put into operation can be gauged by the current need for them.

The entomological records also serve as a yardstick by which to determine the efficiency of larvicidal work. Because of this, a few area supervisors consider the entomologists as being "Gestapo" agents assigned to their areas for sinister purposes. The surest sign that a malaria control supervisor has "come of age" is when he ceases to regard the entomologist with suspicion or as a useless member of his staff, and comes to consider him an ally and an extremely valuable one at that.

On the other hand, on this program it is important that the entomologist overcomes what in many cases appears to be almost a natural instinct for research and recognize the fact that he is a part of a practical control organization which demands the collection of data of immediate value to the problem in hand and the investigation of extraneous details, no matter how interesting, is of strictly secondary importance.

The system of classifying each adult collecting station by a letter indicating its distance from the protected war establishment is an innovation which is of particular value since the importance of high densities of *quadrimaculatus* depends on where they are found. A report of high *quadrimaculatus* abundance in "A" stations is immediately recognized by all concerned as of much greater importance and as requiring quicker action than is a report of as high or higher abundance in "C" or "D" stations. Were stations reported simply as "Station 6" or "Station 5", reference would have to be made to a map or a list of station locations in the area involved before the report could be properly evaluated.

The interpretation of adult *quadrimaculatus* abundance, as indicated by resting station counts, is one deserving of more discussion than is possible here. High *quadrimaculatus* densities and high malaria incidence are not always directly correlated in various sections of the country. A moderate *quadrimaculatus* density in a malarious area must be considered as a greater hazard than a much higher density in an area where malaria has not been endemic. However, the movement of troops and industrial workers from one section to another, and to and from tropical areas, is introducing non-immunes into areas where malaria is endemic and infected individuals into non-malarious areas where effective vectors are abundant. This greatly complicates the war time problem.

The degree to which *quadrimaculatus* populations must be reduced before danger of transmission is eliminated, therefore, cannot be definitely stated. It may vary in each area and a variety of factors must be considered before limits are set. The trend of the adult anopheline population in an area, however, is the only criterion for use in judging the effectiveness of the control work.

PROGRESS IN THE APPLICATION OF LABORATORY METHODS IN THE ARMY'S MALARIA CONTROL PROGRAM*

by

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INTRODUCTION

Malaria stands foremost as a disease to affect the outcome of the war. Since the Fourth Service Command was made up of eight of the most malarious states of the Southeast [1], the control of malaria was given an important place in planning the preventive medicine laboratory program of this Service Command.

The basic principles involved in the control of malaria in the Army are in many respects similar to those in civilian life. A plan for control would include the following factors:

1. Diagnosis, isolation, and treatment of infected cases.
2. Control of mosquito breeding.
3. Chemical prophylaxis where exposure to infected mosquitoes is unavoidable.
4. Individual protection against mosquito bites.

Following the recommendations of The Office of The Surgeon General[2], a laboratory control program was initiated and placed in operation. Because of the importance of the diagnosis of malaria in a control program and the essential role of the laboratory in establishing proper diagnoses, it was necessary to improve and adopt as early as possible standard laboratory techniques for this work.

The next step of the program was the training of technicians from station hospital laboratories in the preparation, staining, and diagnosis of thick and thin blood films. A system was then developed for checking the hospital diagnosis at the central laboratory.

PREPARATION OF GIEMSA STAIN FOR DISTRIBUTION

Considerable difficulty was experienced in obtaining uniform results with some of the lots of American Giemsa stain. The present procedure of the Division of Malariology is to prepare the stock solution for distribution to all station hospitals as needed. Certified lots of dry Giemsa stain are obtained and the staining qualities of the stock solution are tested before distribution by staining fresh thick blood films. After testing, each bottle that is sent out is labeled

*Presented at the meeting of the National Malaria Society in conjunction with the Southern Medical Association, November 10, 1942.

with specific directions as to the proper dilution and use of the stain. This has aided immeasurably in standardizing the staining technique throughout the Service Command. The labels contain the following directions:

Use one part of stain to 50 parts of *buffered* distilled water (pH 7.0). Place smears in staining solution for 45 minutes. Before removing, flush off top of stain with water, then remove slides, rinse and refill container, using buffered water throughout. Replace slides and rinse the thin smears for only a few seconds. Pour off water until it just covers the thick smears, and continue the rinsing for 3 or 4 minutes. Remove and allow to dry by air. *Use only chemically clean glassware.*

TRAINING OF ENLISTED TECHNICIANS IN THICK-FILM TECHNIQUE

An early move to accomplish our objective in establishing and improving proficiency in the laboratory diagnosis of malaria in the station hospitals, was the training of enlisted technicians from the various hospitals. Upon the recommendation of Dr. L. L. Williams, Jr., the assistance of Miss Aimee Wilcox, Assistant Technologist, United States Public Health Service, was secured. Under her supervision a two-weeks course of instruction and training was begun in May, 1941. Three classes were held, and twenty-four men in all received the training.

Additional courses were arranged during the spring of 1942, again under the supervision of Miss Wilcox. Three classes of two weeks duration each were held and a total of forty-eight students completed the course. Forty-two of these were enlisted men from various station hospitals and six were civilian trainees from the Fourth Service Command Laboratory.

In addition to these students, five enlisted men from station hospitals and four civilian trainees have been given special training in the thick-film technique at intervals during the year.

During these courses, the trainees were given detailed instructions on making and staining thick and thin blood smears, and how to recognize the stages and species of the parasites on both types of films. Instruction was given by means of lectures, lantern slides, study of a carefully selected set of known and unknown slides, and practical exercises in the preparation and staining of thick and thin blood films. At the end of the course, a certificate for each student was sent to his laboratory officer stating that he had completed a course in thick-film technique and giving his approximate grade.

Before returning to their stations, the trainees were instructed

to submit to the Service Command Laboratory two thick and two thin smears, one of each stained and one unstained, on each suspected and positive case of malaria found at the station hospitals. These smears were to be accompanied by a form giving certain epidemiologic and statistical information. A set of instructions on the method of preparation and staining of thick blood-films, likewise, was sent to all station hospitals in the Service Command.

About the middle of June, 1941, the first slides were received for confirmation from members of the first training school. On July 1, 1941, a circular letter was sent out from the Corps Area Surgeon's Office instructing the station hospitals to submit smears for confirmation or diagnosis on all positive and suspected cases of malaria.

CONFIRMATION OF MALARIA DIAGNOSIS

Upon receipt of the slides for confirmation or diagnosis, the stained smear is examined and when this is found to be unsatisfactory, the second smear is stained. As a further means of instruction, suggestions are sent to the originating laboratory regarding any defects noted in the stained smear. The statistical form referred to above (Fourth Corps Area Laboratory Form No. 1) is submitted in duplicate with each smear. The two sides of this form, as revised in 1942, or shown in Figure 1. On the reverse side the results of the examination made at the Service Command Laboratory are noted. Special reference is made as to agreement in the identification of the stages of parasites found, and the degree of infection. One card is filed at the Fourth Service Command Laboratory and one is returned to the station hospital. When a smear has been diagnosed as benign tertain by the station hospital laboratory and is found to be estivo-autumnal, a radiogram is sent noting the discrepancy, since estivo-autumnal is considered more dangerous than the other species. A radiogram is sent also when a smear is diagnosed as negative or doubtful and is found to be positive.

The information gathered from the card forms is tabulated at the end of each month to form a malarial epidemiological report for the Chief of the Medical Branch, Fourth Service Command, and The Surgeon General. During 1941 a check was made to correlate the number of clinical cases reported in the Army statistical report with the number of slides received from the station hospitals. This was done to determine the degree to which the station hospitals were utilizing the services of the Service Command Laboratory and cooperating with its plan. The above is mentioned to emphasize the steps taken to confirm, by laboratory methods, the diagnosis of all suspected cases of malaria in the Army in order that they might

be isolated and treated, and thus control the source of infection to others.

MALARIA RECORDS FOR 1941 AND 1942

A total of 892 positive blood smears were received at the Laboratory between June 17, 1941 and September 30, 1942. The distribution of these by states is shown in Table I and by months in Table II. From these tables it may be noted that more than half of the cases during 1941 occurred in September and October and that about 43 percent of these were estivo-autumnal infections. A large proportion of these cases were contracted during Army maneuvers held in a highly endemic area in Louisiana, many of which were first reported upon their return to stations in other states. Louisiana was transferred from the Fourth Service Command in May, 1942, and this should be kept in mind in comparing the records for the two years.

A tabulation of the confirmation made at the Fourth Service Command Laboratory in shown in Table III.

MALARIA SURVEYS

Even though the malaria rate has been comparatively low or generally on the decline in the civilian population of the Southeastern states since 1936, and the military personnel may have a tendency to assume the rate of the group by which they are surrounded, it is conceivable that an outbreak of malaria might occur in troops concentrated in some of our camps if preventive measures were not taken. In order to determine the presence of subclinical cases of malaria and carriers, sampling surveys of various groups of men were undertaken. In 1941 these included: (1) routine admissions to the station hospital at Camp Claiborne, Louisiana; (2) inductees at Fort McPherson, Georgia, from Georgia counties having an average annual malaria death rate of 25 or more per 100,000 during the ten-year period 1930-1939; (3) inductees at Fort McPherson giving a previous malaria history; and (4) hospital admissions and other troops in the Louisiana maneuver area. Only 12 infections, about 0.6% were found in 2,002 examinations, most of which were from the Louisiana maneuver area. During the Fall of 1942 a survey was started of inductees at Fort McPherson from counties having an average death rate of 10 per 100,000. Up to the time of the preparation of the present paper, no infections had been found in 472 slides. A summary of the surveys is given in Table IV.

CONCLUSIONS

A correct diagnosis of malaria is one of the first steps in malaria control and the chief role of a laboratory in a control program. In order to integrate itself with the program of the Office of The Surgeon General for the control of malaria, the Fourth Service Command Laboratory has initiated and placed in operation a plan for laboratory control of the diagnosis of malaria. This plan includes the organized instruction and training of enlisted technicians from station hospital laboratories in the Fourth Service Command, and adoption of a standardized staining procedure, using stains from domestic sources. Finally, the system incorporates a check-up and confirmation of malaria diagnoses by a central laboratory with competent personnel. The operation of this plan, in its entirety, is proving very effective.

REFERENCES

[1] Faust E. C., and Parker, V.: 1940 Malaria Mortality in the Southern United States for the Year 1938, *Southern Med. Journ.,* 1940, Aug., Vol. 33, No. 8, pp. 897-900.

[2] Simmons, J. S.: Progress in the Army's Fight against Malaria. *Jour. Amer. Med. Assn.,* 1942, Vol. 120, No. 1, Page 30.

FIGURE I.

MALARIA THICK BLOOD FILM EXAMINATION FORM

Station Hospital: ____________________

Name of Patient: ____________ Serial Number: ____________

Grade: ________ Organization: ________ Station: ________

Race: ______ Sex ______ Age: ______ Date Enlisted ______ State ______

Where Exposed.—Post or Vicinity: ______ Maneuvers: ______ Other: ______

New Case: ______ Recurrence: ______ Date of Previous Attack: ______ Treatment: ______

Type.—Tertian: ____ Estivo-Autumnal: ____ Quartan: ____ Undetermined: ____ Negative: ____

Stage of Parasites.—Trophozites: ______ Schizonts: ______ Gametocytes: ______

Number of Parasites Found.—Many: ______ Few: ______ Rare: ______

Spleen Enlarged: ______ Hemoglobin: ______ R.B.C. Count: ______

Date Smear Taken: ______ Date Stained: ______ Date Smear Examined: ______

Examined by: ____________ Remarks: ____________

____

____

C. A. Lab. Form No. 1 revised *Signature of Laboratory Officer*

DIRECTIONS

1. Fill out this form *completely* in duplicate and mail with one stained and one unstained thick and thin film packed in cotton in mailing case No. 41260 to the Fourth Corps Area Laboratory.
2. Mail within twenty-four hours after collection of slides.
3. Send slides and completed forms in same container on all positive and suspected cases of malaria.
4. Use new slides for malaria thick film diagnosis whenever possible.
To be filled in by the Fourth Corps Area Laboratory

Lab. No. ________ Confirmed ____________________

____

____

____

____

____

____

____

____

Checked by: ____________________

TABLE I

DISTRIBUTION OF MALARIA CASES CONFIRMED BY THE FOURTH SERVICE COMMAND LABORATORY ACCORDING TO STATES

June, 1941 to September 30, 1942

STATE	1941 Tertian	1941 E.A.	1941 Total	1942 Tertian	1942 E.A.	1942 Total
Tennessee	22	14	36	28	3	31
North Carolina	24	23	46	51	3	54
South Carolina	36	16	52	32	20	52
Georgia	43	23	67*	95	16	111
Alabama	27	4	31	22	8	30
Florida	21	3	24	32	12	44
Mississippi	53	26	79	56	4	60
Louisiana	80	74	154	21	00	21**
TOTAL	306	182	489*	337	66	403

*Includes one case undetermined as to species of parasites.

**Louisiana was transferred from the Fourth Service Command in May, 1942.

TABLE II

SUMMARY OF BLOOD SMEARS POSITIVE FOR MALARIA FOURTH SERVICE COMMAND LABORATORY

	JAN. FEB.	MARCH APRIL	MAY JUNE	JULY AUG.	SEPT. OCT.	NOV. DEC.	TOTAL
1941							
TERTIAN			8	76	151	71	306
E.A.			3	18	117	44	182
Unidentified					1		1
TOTAL			11	94	269	115	489
1942							
TERTIAN	12	45	109	127	44		337
E.A.	1		5	34	26		66
TOTAL	13	45	114	161	70		403

TABLE III

CONFIRMATION OF MALARIA THICK BLOOD FILMS BY THE FOURTH SERVICE COMMAND LABORATORY

	1941	1942
Positive Diagnosis Confirmed as to Type	440	377
Negatives Confirmed as Negative	115	130
Reported Negative, Found Positive	2	6
Reported Positive, Found Negative	27	22
Errors In Identification of Species	47	23
Total Slides	631	558
PERCENTAGE OF ERRORS:		
In Diagnosis of Infection	4.6	5.1
In Identification of Species	7.4	4.1

1942 figures include repeat examinations on four cases.

TABLE IV

MALARIA SURVEYS IN ARMY TROOPS – 1941 and 1942

1941

SOURCE OF BLOOD SMEARS	Period	No. Slides	No. Positive
Routine admissions to Station Hospital, Camp Claiborne, La.	June 20-26	110	0
Inductees from Georgia counties having malaria death rates of more than 25 per 100,000 for the years 1930-1939.	July	110	0
Routine admissions to Station Hospital, at Camp Stewart, Georgia	Aug. & Sept.	122	2
Inductees at Fort McPherson, Ga., giving history of malaria during previous ten years.	September	227	1
Hospital admissions and normal troops in Louisiana maneuver area:			
Camp Claiborne Hospital			
Admissions	September	196	1
Others	September	85	0
Camp Livingston Hospital			
Admissions	September & October	981	8
Others	September & October	100	0
Camp Polk Hospital			
Admissions	September	71	0
	TOTAL	2002	12

1942

SOURCE OF BLOOD SMEARS	Period	No. Slides	No. Positive
Inductees from Georgia counties having malaria death rates of more than 10 per 100,000 for the years 1930-1939.	Sept. 21–Oct. 10	472	0
	TOTAL	472	0

DEVELOPMENT OF ENTOMOLOGICAL SERVICE OF THE FOURTH SERVICE COMMAND LABORATORY AS APPLIED TO THE ARMY'S MOSQUITO CONTROL PROGRAM

by

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(Presented at the meeting of the National Malaria Society in conjunction with the Southern Medical Association, Richmond, Virginia, November 10, 1942.)

INTRODUCTION

When the United States Army began mobilization in the fall of 1940, provision was made immediately by the Medical Department for a program of malaria and mosquito control in the various training camps, particularly those in the Fourth Corps Area which comprised eight of the Southeastern states in the malaria belt. Commissioned sanitary engineers and entomologists from the Sanitary Corps were called to active duty and assigned to the more important camps. Prior to the opening of the mosquito season in 1941, instructions, based on a directive from the Surgeon General, were issued by the Surgeon's Office of the Fourth Corps Area (now known as the Fourth Service Command) as to the procedures to be followed in the control work on the Army reservations. During the Spring of that year, the Corps Area Laboratory was moved from Fort Benning to Fort McPherson, and provision was made in the reorganization for a Department of Medical Entomology, one of the functions of which was to give assistance in the malaria and mosquito control program. The appointment of an entomologist to this position was not effected until Fall.

Following the declaration of war there was a natural increase in the number of Army camps and airfields in this area. Because of the resulting increase in mosquito control activity, it was believed essential to institute within the cantonment areas a uniform and adequate system of mosquito collection records, or indices, as the only feasible means of keeping abreast of developments. Such a system would provide information on (1) those areas having a high population of *Anopheles quadrimaculatus* and therefore requiring a malaria control program, (2) those having other species of serious importance as pests, (3) the sources of production of these mosquitoes, and (4) the efficacy of the control program, both inside and outside of the reservations.

Instructions for the system of collection records were prepared by the Fourth Corps Area Laboratory and were issued in the Spring of 1942, accompanied by a letter from the Corps Area Surgeon directing that collections be made.

INSTRUCTIONS FOR WEEKLY COLLECTIONS

These instructions called for the following four classes of collections to be made at weekly intervals:

1. *Adult anopheline resting station collections.* Previous experience has shown that such collections ordinarily provide the best means for determining the relative abundance of *A. quadrimaculatus,* the one species regarded as of importance in malaria transmission in the Southeast. As is well known, adult *quadrimaculatus* utilize as diurnal resting places such locations as barns, privys, hollow trees, culverts, caves and other dark and sheltered locations. From ten to twenty of the most favorable places available in the vicinity of the cantonment area were to be selected as stations for weekly collections, and where the number of such stations was insufficient they were supplemented with nail kegs or small boxes painted dark red. These were found to be more effective when placed in woods near breeding places.
2. *Light trap collections.* From one to five, or sometimes more, of the New Jersey type of suction light trap have been used at most of the posts. It was recommended that three to five all-night collections per week be obtained from each trap. These collections are of especial value in determining the kinds and prevalence of species of *Aedes* and *Psorophora,* two genera containing some of the most annoying of the pest mosquitoes. The light traps are comparatively less effective as a rule in taking *Anopheles quadrimaculatus* and *Culex quinquefasciatus* (the southern house mosquito), while the yellow fever mosquito, *Aedes aegypti* is very seldom taken in the traps. This must be kept in mind in interpreting the results. Because suitable index stations for *quadrimaculatus* are usually difficult to find in and immediately around the cantonment areas, the trap collections are becoming increasingly useful for this species as comparative records are accumulated. For example, an average of two or three specimens per night now is regarded as approaching an undesirable density level, whereas with the pest species, severe annoyance may not be noticed until the traps show 20 to 50 specimens per night.

3. *Biting records.* These are taken after nightfall and the collecting period is usually of 30 minutes duration. The specimens are caught while attempting to bite the collector and the records give direct information on the relative prevalence of the biting species.

4. *Larval station collections.* Dipping collections for larvae are made in representative parts of all the potential breeding places within a mile of the cantonment area. Inspections should be made outside this radius when pest species are numerous. These collections are of special importance as they provide information on the source of production of the important species and on the effectiveness of the larvicidal work.

In the instructions as issued to the sanitary personnel, it was required that the mosquito material, accompanied by the collection data, be mailed weekly to the laboratory for identification of species or for a check of the identifications made by others. Most of the named specimens are then returned to the originating post where they may be used for study or reference purposes. As this involved the handling and tabulating of a great deal of material, several enlisted men, graduates in entomology, were obtained by transfer to the laboratory and trained in mosquito identification.

RECORD FORMS

Five forms were prepared by the Service Command Laboratory and issued to all the posts for recording the collection and identification data. Forms No. 1 and 2 were made up in 5x8 inch pads for field use in taking notes on adult and larval collections. Forms No. 3 and 4 (Figure 1) have similar headings, but are printed on 8x10.5 inch sheets for the permanent record. No. 5 (Figure 1) was intended for recording collections, particularly those from light traps, in which a variety of species was taken.

The final draft of this set of forms was drawn up by the writers after consultation with members of the Georgia State Department of Health, the U. S. Bureau of Entomology, and the U. S. Public Health Service. The forms were then adopted by the Fourth Service Command and the Federal-State organization for Malaria Control in War Areas. The use of the same forms by the two organizations provided a uniform system of records and exchange of information for the workers in the intra- and extra-cantonment zones.

The weekly reports provide a frequent and fairly accurate index of the mosquito population at the camps where the collections have been adequately made. Increases in the numbers of any species

becomes immediately apparent. Such information is of especial importance of course in the case of *A. quadrimaculatus* and indicates need for more intensive control efforts.

SPECIES CONTROL STRESSED

In the beginning of the work in 1941, the control program was of necessity directed against all species and all possible breeding places. Since the establishment of the Laboratory, stress has been placed on species control and on the training of the personnel toward greater species consciousness. This is essential in the interest of efficiency and economy, since the majority of the 52 species that have been taken are of little or no health importance. As applied to the malaria problem, *A. quadrimaculatus* is regarded as the sole anopheline in this area against which control measures need be directed, which is also in accord with the present policies of the U. S. Public Health Service and the State Boards of Health. In a number of locations where the principal species present has been found to be *A. crucians* or *A. punctipennis,* it has been considered unnecessary to institute, or continue, a large scale larviciding or draining program.

Of the other genera of mosquitoes, the principal species considered to be of primary importance are the two domestic species, *Culex quinquefasciatus* and *Aedes aegypti*, and certain of the so-called wild or pest species in the genera *Aedes* and *Psorphora,* especially *A. vexans* and *P. columbiae.* At some of the posts near the sea-coast the salt marsh species, *Aedes taeniorhynchus* and *Aedes sollicitans,* have been very abundant. In other localities, *Mansonia perturbans, Culex salinarius*, *Aedes mitchellae,* and several of the woods species such as *Psorophora ferox, Aedes atlanticus,* and *Aedes triseriatus* have occurred in annoying numbers.

While the final proof of the effectiveness of the *quadrimaculatus* control work is the absence of human cases, there is a considerable lag in information obtainable from this source. Moreover, it is nearly always difficult or impossible to determine exactly where infection was acquired. Adequate collection records, in fact, if consistently low for this species at any given camp, furnish the strongest evidence available that cases of malaria occurring in the troops at that camp have been acquired elsewhere.

Since a considerable proportion of the personnel assigned to the work had had little or no previous experience in collecting specimens, the project was not carried out as systematically as desired in the earlier stages. Nevertheless, there has been distinct improvement in this respect as the season progressed.

COLLECTION RECORDS

It is not possible in the present paper to give detailed analyses of the collection records, but two tables may be presented, the first showing the total number of specimens identified during the past year (to October 1) at the Fourth Service Command Laboratory (Table 1). The second table shows the total number of *Anopheles quadrimaculatus* adults taken by three collecting methods on the reservations within a mile radius of the cantonment area. In the latter it may be noted that the seasonal average of males and females per collection was .90 in the natural resting places, .14 in the light trap collection and .06 in the biting collections. The collections were received from 59 Army posts and airfields in the seven states now included in this Command (Figure 2). They include material from 3 additional posts in Louisiana prior to its transfer to another Service Command in May, 1942.

The averages in Table 2 indicate a very low *quadrimaculatus* population for the camps in general. As to the individual locations, none of the large camps have shown what could be regarded as a dangerous density level at any time during the season. Nearly all of the *quadrimaculatus* reported have been from a half-dozen small stations and most of these showed distinctly improved conditions before the end of the season. With the possible exception of one or two of these posts there has been little evidence of active malaria transmission in the cantonment areas themselves during either of the past two seasons.

One of the interesting results of the extensive collection data obtained this past season is the discovery that *A. georgianus* is much more widely distributed than previously suspected, having been recorded in all of the South Atlantic and Gulf states from North Carolina to Western Louisiana. There has been no indication, however, that it is of importance in the transmission of malaria. New distributional records for a number of other species have also been obtained.

TRAINING OF PERSONNEL AND MOSQUITO SURVEYS

One of the important functions of the laboratory has been assistance in the training of personnel for the antimosquito work. In the spring of 1942 there were ten commissioned entomologists assigned to the larger camps in the Service Command and arrangements were made for them to attend training courses of two weeks duration at this laboratory. Eight of the ten officers attended the course, which consisted of conferences on mosquito control prob-

lems and training on the identification of species. At the request of various other stations, a number of enlisted men were sent during the year for similar courses. Since most of these had had no previous entomological experience, it was necessary to give them primary training in collecting and control methods as well as in identification of species. It is believed that an enlargement of this training program would be of much value.

Another function of the Entomological Department of the Laboratory, which may be briefly mentioned, is that of mosquito surveys. A considerable proportion of the camps and larger airfields has been visited in order to become familiar with the local problem and to inspect the control work and the system of mosquito collections. In addition, original surveys of some new camp sites have been made by the entomological personnel and recommendations prepared as to the control work needed. The value of such surveys has been demonstrated in several cases in which the absence of *A. quadrimaculatus* in significant numbers made a control program unnecessary. At these places it was recommended that the regular system of collections be carried out to secure information on any future increase in the numbers of this species.

ACKNOWLEDGEMENTS:

The writers wish to express their appreciation for the active cooperation received from the Surgeon and other officers in the Service Command headquarters, and from the medical and sanitary personnel in the various Army camps. Most of the identifications at the Laboratory have been made by Technician 3rd Grade James P. Toffaleti and Corporal L. M. Roth. Lieutenant W. W. Middlekauff has been of much assistance in connection with the work during the latter part of the season.

SUMMARY

A mosquito survey and diagnostic service was organized by the Medical Department of the Army at the Fourth Service Command Laboratory located at Fort McPherson, Georgia. Instructions for collecting mosquitoes and recording data were made uniform for all camps and specimens were submitted to the Laboratory for identification.

In the mosquito control program stress was placed upon the principle of species control and the development of a greater species-consciousness among the anti-mosquito personnel. The following mosquitoes have been listed as of special importance in this area either as disease carriers or as pests: *Anopheles quadrimaculatus,*

Culex quinquefasciatus, Aedes aegypti, Aedes vexans, Psorphora columbiae, Aedes taeniorhynchus and *Aedes sollicitans. Mansonia perturbans, Culex salinarius, Aedes mitchellae,* and a few of the woods species have given considerable annoyance in some localities.

The system of weekly collections provided an index of the mosquito population at each of the camps where adequate records were obtained. The tabulated records furnish immediate information on the status of the important species and the effectiveness of the control work. Similar records for the anopheline species were obtained by Federal and state workers in the extra-cantonment zones.

As a result of extensive collections, *Anopheles georgianus* was found to be much more widely distributed than previously known, having now been recorded from every state in the Service Command with the exception of Tennessee. There is no evidence as yet, however, that it is of importance in the transmission of malaria.

TABLE I.

MOSQUITOES IDENTIFIED FROM ARMY POSTS IN THE FOURTH SERVICE COMMAND THROUGH SEPTEMBER 1942

	May 1942 to April 1942	1942: May	June	July	Aug.	Sept.	Total
Number of Posts	11	21	37	41	40	46	62
Number of Species	34	28	43	45	40	43	52
Number of Larval Specimens	2,605	2,964	4,198	4,839	5,279	5,009	24,894
Number of Adult Specimens	3,968	4,498	18,056	23,049	46,710	40,872	137,152

TABLE 2

COMPARISON OF ADULT ANOPHELES QUADRIMACULATUS COLLECTIONS IN CANTONMENT AREAS IN THE FOURTH SERVICE COMMAND DURING THE SUMMER MONTHS OF 1942

	Diurnal Resting Stations		Light Traps		Night Biting Collections	
	No. Collections	No. quads	No. Collections	No. quads	No. Collections	No. quads
MAY	222	892	249	10	4	1
JUNE	545	562	589	35	102	6
JULY	741	597	697	168	44	1
AUGUST	1,103	842	1,239	191	119	7
SEPTEMBER	1,233	579	1,278	196	122	10
SEASONAL TOTAL	3,844	3,472	4,052	600	392	25
AVERAGE PER COLL.		.90		.14		.06

Form M-3
4th S.C. Lab.

LARVAL MOSQUITO COLLECTION

Post__________ Dates or Station No.__________ Collector__________
Notes__________ Identified by__________

Sta. No.	Location, etc.	Last Larviciding	No. Dips	ANOPHELES							CULICINES	
				No. Collected				No. Identified				Identification
				Total	Small	Large	Pupae	quad	cruc	punct	Total	

Form M-4
4th S.C. Lab.

ADULT MOSQUITO COLLECTIONS

Post__________ Date__________ Collector__________
Notes__________ Identified by__________

Sta. No.	Location, etc.	ANOPHELES										CULICINES		
		quad		cruc		punct		other		Total		Total		Species
		M	F	M	F	M	F	M	F	M	F	M	F	

Form M-5
4th S.C. Lab.

ADULT MOSQUITO COLLECTIONS - ALL SPECIES

Post__________ Station No. or Dates__________ Collector__________
Notes__________ Identified by__________

Species	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
A. quadrimaculatus																																				
A. crucians																																				
A. punctipennis																																				
A.																																				


POSTS SENDING MOSQUITOES
TO THE
FOURTH SERVICE COMMAND LABORATORY

STATE AND LOCAL ORGANIZATIONS FOR MALARIA CONTROL IN WAR AREAS

LOUVA G. LENERT, *Associate Engineer*
W. A. LEGWEN, *Assistant Engineer*
Division of Public Health Engineering, Georgia Department of Public Health

The responsibility for conducting the Malaria Control in War Areas program in Georgia was delegated by the U. S. Public Health Service to the State Department of Public Health early in 1942.

In the state department, malaria control operations are a normal function of the Division of Public Health Engineering, and entomological and epidemiological phases are conducted by the Division of Malaria and Hookworm Service.

MOSQUITO CONTROL BY LOCAL HEALTH DEPARTMENTS

In 1941, when the Public Health Service made funds available to the states for mosquito control in extra-cantonment areas, labor was employed, oil was purchased and operations were carried on by the local health departments through the Division of Local Health Organizations. The Malaria and Hookworm Division rendered considerable assistance by selecting and training inspectors who were assigned to work with the local departments.

WPA MOSQUITO CONTROL

This arrangement lasted until July 1, 1941, when funds were exhausted and the Work Projects Administration was directed by the Bureau of the Budget to continue mosquito control work. There was a state-wide malaria drainage project already in operation so changes were made in the project description to permit the purchase and application of larvicidal oil. As the sponsor's representative on the WPA state-wide malaria drainage project was in the Division of Public Health Engineering the overall direction of the work, if it could be so described, was in this Division. It was impossible to convince the WPA management that inspectional service was essential so the program resolved itself into one of oiling every particle of standing water as nearly once each week as was possible. Sometimes this was done, if the rules and regulations did not interfere and, on occasion, periods were as long as three weeks to a month because oil purchases were not planned sufficiently far in advance.

No cases of malaria, as far as could be learned, were contracted in the military areas during 1941. Whether this was due to the unusually dry season, good control of mosquito breeding, the ex-

tremely low ebb of the malaria cycle, or a combination of all was never decided.

MALARIA CONTROL IN THE WAR AREAS

The change-over from mosquito control to malaria mosquito control in 1942 required drastic revisions in operating procedure.

Experiences of the past season demonstrated the necessity for a well organized inspectional service upon which control operations could be based. It was decided that such inspectional service would be set up in every war area where malaria might be of potential importance, even though former records might indicate that it was of slight significance. This inspectional service was set up by the Malaria and Hookworm Division in each imporant area before *A. quadrimaculatus* mosquito breeding started. All potential breeding places were marked and numbered and weekly inspections were made of each station.

Until *A. quadrimaculatus* larvae were found and identified no control measures were started, except for preliminary organization and some minor clearing and drainage. No labor was employed in doubtful areas until the inspection service showed the breeding to be of sanitary significance. After a station was proven " 'quad' positive" larvicidal operations were begun, and that station was placed on the schedule for weekly larviciding. Additions to this schedule were made as new stations became "quad" positive. As soon as larviciding operations were started the inspection work was so coordinated that stations were checked the day *after* larviciding to determine the effectiveness of control operations.

The control of *A. quadrimaculatus* breeding may be accomplished with several larvicidal agents, the most common of which are oil and Paris green. In Georgia it was decided to use Paris green dust for several reasons. Oil is difficult to transport, messy to apply, ineffective in vegetation, objectionable to property owners, unsightly, and complications in transportation made its delivery throughout the season seem rather problematical. Not one gallon of oil has been purchased for malaria control in war areas in Georgia during 1942.

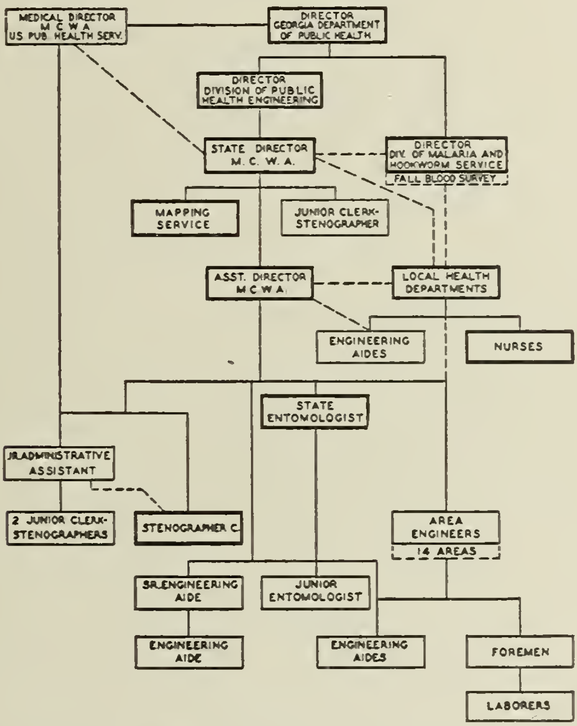
STATE ORGANIZATION

The State Organization was therefore based upon 1) a complete inspectional service which would give an accurate picture of *A. quadrimaculatus* production at all times, 2) a weekly larvicidal schedule on all positive breeding areas using Paris green dust as the larvicidal agent, and 3) an engineering organization which is

capable of planning and executing such drainage projects as are necessary to either eliminate larvicidal operations entirely or make them more effective.

A staff member of the Engineering Division of the State Health Department was designated as the Service representative in the State and was made responsible for all control operations. Entomological phases, begun under another division, were taken over in June by loan of a staff member so that all phases could be grouped under a common head for operational convenience.

ORGANIZATION CHART
MALARIA CONTROL IN WAR AREAS
STATE OF GEORGIA



The attached chart (Plate I) shows the organization, intensified blocks being used to illustrate State participation in the program. The chart is probably incomplete in some phases, but it serves to illustrate the malaria mosquito control organization.

The mapping service shown is a normal engineering division activity diverted to assist the malaria control program as much as may be necessary. Maps are prepared from aerial photographs,

usually those flown for the AAA. Plate II shows a typical area so mapped including all ponds, ditches, streams, woods and houses, as well as highways and railroads. The numbers following the zone designation show the location of larval stations (V65). Adult catching stations are shown with letters (C).

The state organization (Plate I) for discussion purposes may be divided into three units, 1) administrative, 2) entomological, and 3) control.

The administrative unit, while under state direction is obviously subject to certain Federal procedures, specifications and regulations which require a certain amount of joint management.

30

MALARIA CONTROL IN WAR AREAS
U.S. Public Health Service
605 Volunteer Building
Atlanta, Georgia

FOREMAN'S OPERATIONS REPORT

Larvicide and Minor Drainage

(Use one line for each type of work done)

Area 8 Valdosta
Zone Valdosta
Crew one
From ______ to 10/13 194[illegible]

Date	Operating Station		Work Done: Larvicide Application				Work Done: Other Work		Clearing		Time		
	No.	Map Designation	Oil Gals.	P. Green lbs.	Ditches Lin. Ft.	Ponds Sq. Ft.	Incident. Ditching Lin. Ft.	Ditch Clean. Lin. Ft.	4' Wide or Less-Lin. Ft.	4' Wide or More-Sq. Ft.	Start	Stop	Man Hours
	15	Canal		1.1	1000						8^{00} a.		
	20	Swamp		.7		43560							
	25	Ditch		1.1	3000								
	50	Ditch		1.	3000								
	55	Swamp		.4		24000							
	60	Canal		.3	1000								
	64	Ditch		.3	1500								
	71	Pit		.3		21500							
	85	Swamp		5.2		300000							
	90	Pond		1.5		62000							
	96	Canal	✓		3000								
	101	Canal	✓		2000								
	112	Pond		.2		8000						5^{00} Pm	32

Truck No. 1751
Truck Miles 32
Gas (truck) 10
Oil (truck) ______
MCWA - 204

Total men on crew 4
Field time lost because of rain (man-hours) 0
Water surface Eliminated by incidental ditching (Sq.Ft.) 0

Rufus Hillman
Foreman

Plate III

Entomological phases are under the direct supervision of the State Entomologist. He is responsible for the selection, training and technical direction of the engineering aides (inspectors) in local areas. He has direct supervision over the entomologist who identifies or confirms field identifications of all mosquito larvae and adults sent to the state laboratory. He also supervises the senior engineering aide and others in the state office who prepare the weekly progress reports, M-3 and M-4, and the monthly summaries, M-6, furnished to the Service and others.

LOCAL ORGANIZATIONS

The control units are the direct responsibility of the area engineers. Consisting usually of area engineer, engineering aides, foremen and laborers they are under the direct supervision of the assistant state director, with the cooperation of the local health departments. The control unit is integrated as much as possible with the local health department. The shortage of experienced sanitation personnel in each local department made it necessary to furnish and train the engineers, entomologists and engineering aides used to carry on field operations. Technical guidance, and administrative detail required in handling Federal employment and purchases, make necessary the semi-autonomous arrangement within the local health departments.

The area engineer in charge of a control unit may be an engineer, an entomologist or an engineering aide. It is his responsibility to see that all phases of the work in his area function properly.

The inspectors are under the area engineer's administrative jurisdiction. They make all inspections, fill out the required inspection forms (M-1 and M-2) and send all specimens to the state laboratory for identification or verification.

The foreman supervises all larvicidal and other labor operations and keeps an accurate daily record of activities under his supervision (Plate III).

From the reports of the inspectors and foremen the area engineer maintains a monthly operations summary chart (Plate IV) for his permanent record. This shows at a glance when inspections were made, their findings, date for larviciding, amount of larvicide used and the extent of each breeding station in the area.

The area engineer also prepares a weekly operations report (Plate V) for the state office, and semi-monthly progress reports for submission to the Service. These are readily abstracted from the inspectors's and foreman's daily reports.

In those areas surrounding military establishments which operate a control program within the reservation boundaries the area engineer maintains close contact with the medical inspector, exchanging reports of larval and adult mosquito inspections so that coordination of the work inside and outside of the reservation boundaries can be effected.

OPERATING MANAGEMENT

The weekly operations report from the area engineer is the state office guide of operations and contains practically everything necessary to show actual conditions for the week. The entomological

WEEKLY OPERATIONS REPORT

ZONES Valdosta

AREA NAME Valdosta AREA NO. L8

FROM 10/12 TO 10/18/42

SHEET 1 OF 7

STA. NO.	DATE LAST QUAD. +	DATE LARVICIDED OIL	DATE LARVICIDED DUST	DATE INSPECTED LARV.	DATE INSPECTED ADTS	COLLECTIONS LARVAE A.	COLLECTIONS LARVAE Q.	COLLECTIONS LARVAE NA	COLLECTIONS ADULTS A.	COLLECTIONS ADULTS Q.	COLLECTIONS ADULTS NA	DATE FOREMAN NOTIFIED	DATE LARVICIDE RE-APPLIED	REMARKS
V 1a				10/12		20	0	25						
b				10/12		0	0	0						
5	9/14		10/13	10/14		0	0	17				new		
7				10/12		24	10	10				10/12	10/15	
–			10/15	10/16		0	0	0						
14				10/12		D	R	Y						
15a	8/24		10/13	10/14		0	0	0						
b				10/13		D	R	Y						
20	8/24		10/13	10/14		0	0	0						
22				10/12		0	0	0						
23				10/13		1	0	5						
25	10/7		10/13	10/14		0	0	0						
25a			10/14	10/13		32	0	8						
b			10/13	10/14		0	0	0						
c			10/13	10/14		0	0	0						
d			10/13	10/14		0	0	0						
e			10/13	10/14		0	0	0						
30a				10/12		D	R	Y						
b				10/12		3	0	7						
c				10/12		D	R	Y				new		
d				10/12		20	5	22				10/13	10/15	
–			10/15	10/16		D	R	Y						
e				10/12		D	R	Y						
f				10/12		2	0	12						
34				10/12		0	0	24						
b				10/12		0	0	0						
c				10/12		0	0	0						
35				10/12		0	0	0						

PARIS GREEN: ON HAND 510 USED 90 BALANCE 520 ORDER

OIL: ON HAND 1600 USED 900 BALANCE 700 ORDER

REMARKS:

Geo. A. Thompson, Jr. AREA ENGINEER

LEGEND: + = Positive; A = Anophelines; Q = Quads; NA = Non Anophelines

Plate V

'Quad' Positive Sheet For The Week of October 12-17, 1942

	New Larval Stations	Old Larval Stations
Albany	None	T37, U7
Americus	None	A5
Augusta	C34	C101
Bainbridge	A42, A64, C36, C48, C61, V12a	None
Brunswick	None	C25
Douglas	A1, A5, A18, D25	None
Hinesville	K1	None
Macon	V7f, V15e	W1b
Moultrie	C45b, C60, S16	C40, C88, E13
Savannah	None	P1, P3, P8, P13, Q1, Q5, Q6, Q7, Q12a
Valdosta	V7, V30d, V36	C12

	New Adult Stations	Old Adult Stations
Albany	DA3	TF1, TK1, UA2
Americus	None	AB, CD
Augusta	None	CA1
Bainbridge	None	WA
Brunswick	None	None
Douglas	None	None
Hinesville	None	None
Macon	None	WB3, WB4, FB1, FB2, FI
Moultrie	None	CC, BA, SA1
Savannah	None	AY, MF, MK, PA, PD, PF, PE, QA, QB, QC, QJ, SO
Valdosta	VH	VK2

Plate VI

service in the state office checks the identifications and numbers of larvae and adult mosquitoes before they reach the assistant state director for analysis. This report reaches its destination by Tuesday of the following week so that ample warning is received regarding any unusual condition not already known to the state office. Field contacts from the state office may then be made in accordance with actual requirements instead of making unnecessary routine visits.

A very helpful condensed analysis of the weekly summary sheets is contained in the 'Quad' Positive Sheet (Plate VI), which lists each positive larval and adult station in the entire state. They are grouped into old and new stations according to whether they have been positive in previous weeks and are therefore under larvicidal treatment, or whether they have been found positive for *A. quadrimaculatus* for the first time. A glance at this sheet gives a quick picture of the program for the week and indicates trouble spots which may require further analysis.

CONCLUSIONS

The organization and operating procedures outlined above seem to have been rewarded with considerable success. In the beginning it was somewhat difficult to reconcile those who were insistent on complete mosquito control. In two areas under larvicidal treatment accurate records of accomplishments were sufficient answer for critical reports on the scope and management of operations.

One area, in a county which carries out a county-wide larvicidal control program, has been furnished standard inspectional service which has resulted in materially improving control results and has indicated the need for certain drainage improvements which will reduce the necessity for larviciding.

In three areas inspection service was maintained without control measures being instituted. In the first, although a mild malaria epidemic appeared within twelve miles, inspection service showed that no control measures were necessary in the area. In the second area, military authorities insisted that control operations should be instituted, but inspection service demonstrated that the principal mosquito was *Anopheles punctipennis* and that *A. quadrimaculatus* was very rarely found. Not entirely satisfied with these statements a separate inspection service was set up by the Army. To date only five "quads", larvae and adults combined, have been recovered in the vicinity of this establishment. In the third area, the local health department did not consider control operations necessary and inspection service was not started until late in the season. Several *A. quadrimaculatus* breeding places of potential importance

were located and these will be corrected by drainage operations during the winter months, so that the local larvicidal program will be effective during the next mosquito breeding season.

In conclusion, success in any venture can be attained only by diligent application on the part of each individual to the task to he or she has been assigned. The apparently successful malaria mosquito control operations in Georgia during the 1942 season are principally due to the ingenuity, resourcefulness, enthusiasm and loyalty of those associated in this work.


Joree Pond
Emory Junior College
Georgia State Womans College
Remerton Cotton Mill and Village
VALDOSTA
Atlantic Coast Line R.R.
EXTRA CANTONMENT ZONE
VALDOSTA AND ACCESS ROAD
DEFENSE AREA VALDOSTA GA
Prepared by C.H.E.
GEORGIA DEPARTMENT OF PUBLIC HEALTH

Plate III

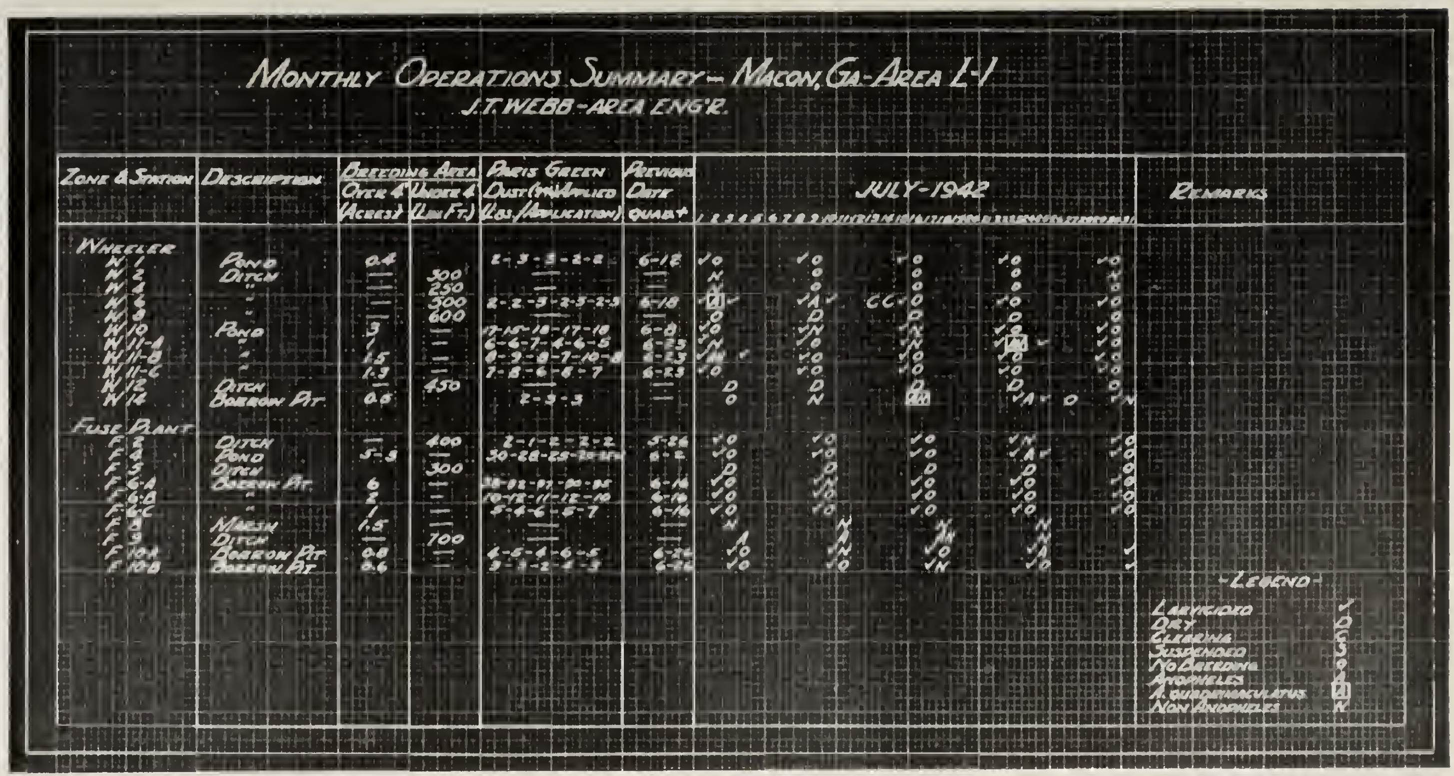

MONTHLY OPERATIONS SUMMARY — MACON, GA.-AREA L-1
J.T. WEBB-AREA ENG'R.
ZONE & STATION
DESCRIPTION
BREEDING AREA
OVER 4' (ACRES)
UNDER 4' (LIN. FT.)
PARIS GREEN DUST (LBS./APPLICATION)
PREVIOUS DATE
JULY-1942
REMARKS
WHEELER
FUSE PLANT
-LEGEND-
LARVICIDED
DRY
CLEARING
SUSPENDED
NO BREEDING
ANOPHELES
A. QUADRIMACULATUS
NON ANOPHELES

PLATE IV

COMMUNITY EDUCATION FOR MALARIA CONTROL[1]

by

TRAWICK STUBBS, *Assistant Surgeon*

and

MAYHEW DERRYBERRY, *Senior Health Education Analyst*

THE PROBLEM

Although a soldier receives protection against malaria in his camp and the mile-wide zone immediately surrounding it, he is still subject to the danger of contracting the disease while visiting communities five to ten miles distant. Because of recent transportation shortages, most of these visits are made by walking the distance, and most of the walking is done in the evening when the danger of malaria transmission is greatest. Hence, the intensive malaria control program within the camps, conducted by the armed forces, and in the mile-wide contiguous zones, conducted by the office of Malaria Control in War Areas of the Public Health Service through State Health Departments, do not completely protect the soldiers.

Decreasing the endemic reservoir of malaria in this larger area, five to ten miles from camp, would be far too expensive in manpower to attempt as part of the regular program, and must depend to a large extent upon community cooperation. This meant that the people in these areas had to be informed of the danger and stimulated to do something about it. Such a task was no ordinary job for a malaria control worker. It required specialized training in health education, a field with technique of its own quite different from those of larviciding. The office of Malaria Control in War Areas, therefore, solicited the aid of the Section of Health Education of the Public Health Service in working out a plan for a program. Early in May, 1942, the two offices developed a cooperative malaria education program which was operated by the Public Health Service Education Section through State and County Health Departments. The program was restricted to a few areas so that on the basis of this year's experimental work a comprehensive program for next year might be better planned.

The Program

Health officers in seven states recruited 26 assistants in Health Education who were all assigned to local health officers for their work. With the exception of one sanitary engineer, these were all educators who had the summer months free. An attempt was made to get people who had experience in both science and public relations. In the end, 5 principals or superintendents, 12 teachers of

[1] Presented at the National Malaria Society meeting in Richmond, Virginia, November 10-12, 1942.

science, health, or physical education, 8 high school or junior high school teachers, and 1 grade school teacher were selected. In most instances these were chosen on the recommendation of the local health officer.

Since there were no trained personnel available, it was felt that these people, after a two-weeks intensive training course, could best do the job. They were taught the facts of malaria by such experts as Dr. Louis L. Williams, Jr., Mr. J. A. Le Prince, Dr. M. A. Barber, Dr. F. L. Roberts, and Mr. J. L. Robertson, Jr. Three health educators of the Public Health Service provided group and individual training in the techniques and philosophy of community education.

The spirit of the trainees indicated that the program would be a success. To these neophyte health educators this was more than a summer job; more, in fact than just an opportunity to help advance the health of their respective communities. They were eager to return home to stimulate local people to discover, meet and solve local problems.

Aware of the skepticism with which many professional health workers would view their experiments, they nevertheless entered upon their duties as members of their local health departments with enthusiasm. They spent the next two or three months working among their own people not as malaria experts, but as teachers whose aim it was to arouse the community to take action for the control and prevention of this disease.

In many places the malaria problem was most important among the Negroes. This meant that a number of Negro groups had to be informed about and interested in what had to be done. One trained worker, therefore, was assigned to work among the Negro Teachers' Colleges throughout the South to interest Negro school teachers in returning to their communities in the fall and getting their neighbors to take up the fight against malaria. In one State a Negro teacher was employed to work on the local level in the same way as the rest of the assistants in Health Education.

RESULTS

A final appraisal of the results of the program is, of course, impossible at this time, but certain accomplishments and reactions to the work can be listed.

The malaria problem was presented to over 35,000 people; 685 meetings were held with white audiences and 349 with colored audiences. In addition, 10,000 were influenced individually. Countless others were reached by 360 news articles, 63 radio programs,

and 83 special exhibits.

Mayors of several towns called mass meetings at which various health officials presented the malaria control problem. In many places citizen committees were formed which soon became active in stimulating screening and larviciding programs.

A malaria skit was presented before 1800 people during the intermission of a band concert. "Dr. I. Q." quiz programs, complete with candy bars, were held. The questions asked the contestants were principally about malaria.

Although the total effect of these educational efforts will never be known, the immediate results have been very encouraging.

Screen repairs have been made on 1500 houses, and 460 have been mosquito proofed.

Spraying and oiling has been inaugurated in 790 places and 140 minor drainage activities have been undertaken.

The students of a number of vocational schools helped by building screens for 25c each.

Clinic groups were utilized and in one instance an all-year malaria education program was established in a prenatal clinic.

One hundred Boy Scouts, after dividing a community into 10 zones, accurately recorded every potential mosquito breeding place so that an engineer could follow up to check on mosquito production.

In one community 60 interested citizens toured the nearby countryside to get first hand information on malaria control.

Numerous interesting techniques of group action against malaria were developed. Negro teachers are crusading against malaria amongst people never before even reached.

Letters from various state and local health officers are packed with such phrases as: "Exceedingly well pleased," . . . "Work most valuable," . . . "A valuable asset," . . . "An excellent piece of work," . . . "Stimulated a great deal of interest in malaria and malaria control work," . . . "Did a great deal in bringing about a better understanding concerning malaria control and prevention."

These results justify the conclusion that the experiment in Education for Malaria Control is worthy of continuation and expansion. As encouraging as the results have been, they do not present a full picture of the significance of this program.

SIGNIFICANCE

*During the summer of 1943 the program was expanded to cover 90 counties in 13 States and the same proportionate tangible results were obtained.

1. This type of program emphasizes the local nature of the

malaria problem, and stimulates the people whose problem it is to do something about it.

2. Study of the malaria problem by the community does not stop with the cessation of this immediate program. There is a carry-over into innumerable study groups among school children and their parents. It emphasizes the value of a closer tie-up between the health department and the school.

3. One cannot overemphasize the influence of this educational work in transforming the present emergency program sponsored by the Federal Government into long range full-time programs by local people. One of the most discouraging experiments in malaria control work has been to see splendid programs, financed by funds from outside the community, utterly fail when those emergency funds were withdrawn, and see the burden of malaria again fall heavily upon the community. This educational program offers one possible solution to such failures.

4. This experiment illustrates a type of Public Health Education that is successful. Malaria workers may well be proud that their field has demonstrated an effective educational technique—one which will no doubt come to be more and more an integral part of Public Health work.

5. Even more significant than these other four points is the fact that here is a practical demonstration of Democracy at work. One need not apologize in these days for saying that even here in a program like this there are questions more fundamental and basic than Malaria Control. Honest thinking about this war forces us to be reminded that some of our greatest enemies are not those across the ocean, but rather those within our own country, for example, our negligence in facing our own individual problems and taking responsibility for solving them in democratic fashion; and our failure to realize that democratic action is not only political, but applies as well to other categories of community and national life. We believe that this program is more than just another public health experiment; it is an experiment in basic democratic functions. The success of such an undertaking offers a basis for optimism not only in the immediate efforts to prevent disease, but also, in these dark days it holds ever before us the hope of hastening the day when man, in his struggle against his enemies, including the scourge of malaria, will emerge victorious and triumphant.

MALARIA CONTROL EXPERIENCE WITH CIRCULAR JOINT DITCH PAVING SLABS AND AUTOMATIC SIPHONS*

W. A. Legwen

At the November 11, 1941, National Malaria Society meeting in St. Louis, Missouri, several papers were presented by the members of the Georgia Department of Public Health. One of these papers[1] described the design of a new type ditch paving and another[2] presented the design and suggested application of an automatic siphon for malaria control purposes.

In order to supplement these papers with additional operating data, a brief summary is given of subsequent experience with the use of the two described devices.

CIRCULAR JOINT DITCH PAVING

During 1942, two projects producing and installing this type paving have been in continuous operation. One, the first to produce this type of paving, was operated under the mosquito control program at Fort Benning, Georgia, beginning production in 1941. During the first nine months of 1942, this project produced 31,539 square feet of ditch paving and installed 39,654 square feet. The project was operated with labor hired under Civil Service procedure by the Post Engineer, with the technical guidance of the Post Sanitary Officer.

At Camp Stewart, Georgia, a paving program was incorporated in the WPA drainage project which was sponsored by the Georgia Department of Public Health and the U. S. War Department. This project began operation about the middle of December, 1941, and has been in operation since that time. Through July 10, 1942, the production and installation of all paving was performed by WPA labor. During this time, the project produced approximately 800 cubic yards concrete paving and installed approximately 710 cubic yards. Since July 10, WPA personnel available has been sufficient only for concrete casting purposes, and installation has been effected by labor employed by the Post Engineer.

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*Presented at the joint meeting of the National Malaria Society and the American Society of Tropical Medicine, Richmond, Virginia, November 12, 1942. The author desires to acknowledge his indebtedness to Messrs. M. H. Goodwin, Jr., Jas. C. Burgoyne, Morton Merron, and Robert Lofton for their considerable assistance in the siphon installations and studies.

Man Hour Requirements. Any comparisons of financial costs of various types of paving must be closely analyzed to avoid incorrect conclusions. Concrete materials per cubic yard of concrete vary only as to actual costs and this is generally due to geographical locations of the projects and the sources and types of materials. Labor costs vary a great deal due to the type of projects, supervision and pay rates allowed. From general construction experience and analyses of published data, the most reliable index for comparison purposes appears to be man hours of labor per unit.

In addition to data from the Fort Benning and Camp Stewart project, comparable operations data have been secured from other WPA ditch paving projects in the immediate vicinity of Camp Stewart. These projects employ the parabolic Panama invert paving with rectangular jointed wing slabs for the larger sections. Portland cement butt-joint paving slabs have been installed by the Camp Stewart Post Engineer personnel. In previous experience in this state, for malaria control purposes, butt-joint inverts of any design have been unsatisfactory due to displacement and weed growth.[3]

All of the aforementioned data are included in the following table of man hours per cubic yard of concrete paving:

Table 1—Man Hour (Per Cubic Yard) Comparisons

Location	Period	Labor	Operation	Type Paving			
Fort Benning	1941-42						
Fort Benning	Prior July '42	C. S.	Casting	Circular	16.9	——	——
Camp Stewart	Prior July '42	C. S.	Installation	Joint	38.8	——	——
Camp Stewart	Prior July '42	C. S.	"	Parabolic	25.7	——	——
Camp Stewart	Prior July '42	WPA	"	Panama	——	43.2	——
Camp Stewart	Prior July '42	WPA	"	Invert	24.4	——	——
Camp Stewart	Prior July '42	WPA	"	Portland	25.0	——	——
Project I	Since July '42	WPA	"	Cement	9.5	——	8.8
Project I	Since July '42	WPA	"	Butt-joint	——	25.8	——
Project II	Since July '42	WPA	"		——	36.5	——
Project II							

1. Legwen, W. A., and Lenert, Louva G., Circular Joint and Concrete Form Design for Precast Inverts for Malaria Control Ditch Lining.
2. Legwen, W. A., and Howard, R. S., Jr., Design and Application of a New Type Automatic Siphon for Malaria Control.
3. Andrews, Justin, Howard, R. S., Jr., and Turner, E. Archer, Malaria Control Ditch-Lining Experience in a South Georgia County.

All of these papers were presented at the National Malaria Society meeting, November 11, 1941.

From the preceding data, it will be seen that this type paving compares favorably with other acceptable types which have been in use for some time. The variation in labor for different plants em-

ploying this slab can be attributed mainly to the regulations governing the operation of the various projects.

Concrete Forms. The first forms at Fort Benning were cast from wooden patterns furnished by the Georgia Department of Public Health, and the first forms at Camp Stewart were also cast from wooden patterns made with camp facilities. The Georgia Department of Public Health secured a set of metal patterns and furnished these to the Camp Stewart and Fort Benning authorities and most of the subsequent forms cast were made from these patterns. The concrete forms proved entirely practical, more economical, and have a greater life than wooden forms.

THE AUTOMATIC SIPHON

During 1942, two of the automatic siphons (12" minimum head model) have been installed. These siphons were precast in three sections as described in the original paper. Mr. A. J. Kirby, Public Health Engineer in Bullock County, Georgia, described and constructed the necessary forms and produced an almost perfect casting job. One of these siphons was installed in Liberty County beginning July 11. Its main purpose was for the control of anopheline breeding in a roadside ditch 2700' in length with an average grade of 0.1%. This ditch was fed by an artesian well with a flow of approximately 4 to 6 gallons per minute. Due to the low head available, this 12" minimum head siphon had to be modified so that it would operate under a 1" minimum head. This modification was made by replacing the standard priming vent with another at a higher elevation, connected through the cover of the siphon and into the throat. The siphon has adequately demonstrated that very small flows are entirely sufficient to actuate the siphon and it permits no leakage or over-flow. The reservoir impounded by the siphon's dam required three to four days to fill and was drawn down 1' by the siphon in approximately 40 minutes.

Prior to the installation of the siphon, *A. quadrimaculatus* breeding had been observed in this ditch and larvicidal control measures were instituted. During the period of this siphon's operation (August-September 1942) and in the absence of other control measures, no anopheline breeding could be detected. As a measure of its efficiency as a malaria control device, the siphon's operation was broken by permitting air to enter the throat of the siphon, allowing the normal flow of the well to pass through the siphon and inundate the ditch. Within fourteen days, fourth stage *A. quadrimaculatus* larvae were collected from this ditch.

A second siphon was installed in Baker County, Georgia, at

DeSoto Springs, construction being started on August 25, 1942. The pool created by the flow from the springs (30 to 240 gallons per minute) provided an excellent *A. quadrimaculatus* breeding area. This site was favorable for a demonstration of the siphon's efficiency as a fluctuation device and for a further study of its hydraulic characteristics. It was unfavorable in that considerable difficulty was encountered in securing and maintaining a water tight dam due mainly to the high porosity of the soil.

Measurements of the flow capacity of this siphon revealed an increase of approximately 60 to 65% over that of the original sheet metal siphons. At the listed heads, the following flows in gallons per minute were observed: 1.2' = 1020, 1.5' =1180,1.8' = 1310. and 2.1' = 1460. The error of observation will not exceed 5%.

The increase in flow capacity observed was undoubtedly due to the improvement in streamlining in the concrete siphon. This increase was beneficial in that the discharge period was reduced but the high velocity in flow permitted entrance of air into the siphon at a higher elevation than originally designed and it resulted in imperfect breaking and sealing. This condition was remedied by replacing the ¾" sealing vent with one of ¼" size. Since this replacement, the siphon has operated perfectly and no further modifications are apparently necessary.

Due to the short period of operation and the lateness of season, conclusive evidence of this siphon's efficiency as a malaria control device cannot be given. It has been demonstrated, however, that the siphon is efficient for fluctuation purposes and it may be reasonably expected that results obtained by other malariologists using fluctuation as a control measure will be obtained by the use of this device. It has been definitely noted that large quantities of flotage and numerous anopheline larvae have been drawn into the the siphon and discharged downstream. This siphon and breeding area will be kept under observation and further data will be collected and presented at a later date.

Unpaved

Camp Stewart, Georgia

Paved

Slab Combination

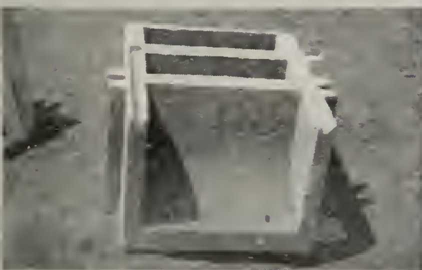
Metal Pattern

Plate I

Precast Concrete Siphon

Cover

Mid-Section



Base

Assembled Siphon

No Flow

Full Flow

DeSoto Springs Installation

PLATE II

TRANSIT-PLANE TABLE TOPOGRAPHIC MAPPING USED FOR MALARIA CONTROL DRAINAGE*

W. A. Legwen

Engineers familiar with topographic methods have long recognized the advantages of the plane table. This instrument generally consists of a convenient sized drawing board mounted on a tripod with a leveling and clamping device, and on which full mapping operations are performed with the use of an alidade. The horizontal and vertical positions of the desired points are determined with the alidade and the operator locates these points graphically on the mapping sheet which is attached to the drawing board. Detailed descriptions of the instrument and its use are found in civil engineering handbooks.†

Principal advantages of the plane table method are: 1) stations may be located independently, obviating cumulative errors; 2) all sketching is done in the field where the topographer can see the form of the ground he is mapping; 3) elaborate notes or retentive memory are not required; 4) missing detail is readily obvious and superfluous information is dispensed with.

Disadvantages of the plane table method are: 1) an alidade is required and as this instrument is not adaptable for other engineering uses it is available only in large or highly specialized organizations; 2) accuracy of mapping operations is limited by the skill of the operator rather than by field measurements, and there are few competent alidade operators as compared to transitmen; 3) isolation and correction of errrors are difficult due to lack of computable data; 4) its operation is entirely dependent upon favorable weather.

In the fall of 1937, the writer had occasion to map a malaria mosquito breeding area in Richmond County, Georgia, comprising abandoned brickyard pits, characterized by irregular shore lines, numerous small dikes and islands, and large numbers of watered areas. A plane table survey was indicated, but an alidade was not available and it became necessary to devise some other method of field mapping procedure. This method, based upon standard engineering field and office practice, has been designated "transit-plane table method." It proved to be entirely satisfactory for the occasion and with slight modifications has been used very successfully since that time on various difficult mapping operations. Ex-

*From the Division of Public Health Engineering, Georgia Department of Public Health, Atlanta, Georgia.

Presented at the joint meeting of the National Malaria Society and the American Society of Tropical Medicine, Richmond, Virginia, November 12, 1942.

†American Civil Engineers' Hand Book, 5th Edition, Pages 472-4.

perienced alidade operators who have become acquainted with this method, have unanimously adopted it in preference to the plane table method.

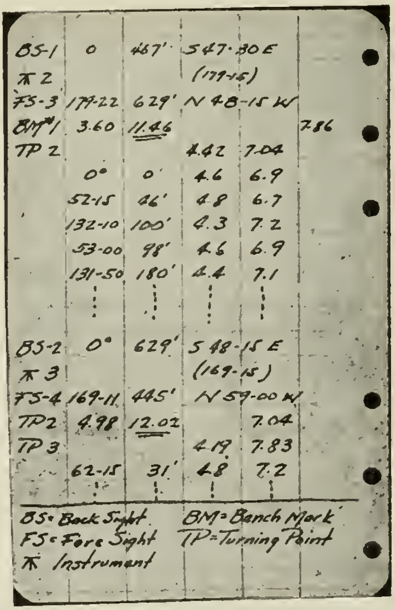
The consecutive stages of the transit-plane table method are described as instrument work, plotting, preparation of plans, and field layout, as follows:

INSTRUMENT WORK

The required equipment comprises a transit with stadia hairs (in good adjustment), field book with natural tangent tables, axe, two to four stadia rods, one level rod, and necessary clearing tools.

Personnel consists of a transitman, two to four rodmen, and one to four axemen.

In operation the transit is set up over the traverse station, zeroed on the backsight — B. S. (usually a traverse station) and the stadia distance and magnetic bearing observed. All observations



BS-1	0	467'	S 47-30 E		
⊼ 2			(179-15)		
FS-3	179-22	629'	N 48-15 W		
BM#1	3.60	11.46			7.86
TP 2			4.42	7.04	
	0°	0'	4.6	6.9	
	52-15	46'	4.8	6.7	
	132-10	100'	4.3	7.2	
	53-00	98'	4.6	6.9	
	131-50	180'	4.4	7.1	
	⋮	⋮	⋮	⋮	
BS-2	0°	629'	S 48-15 E		
⊼ 3			(169-15)		
FS-4	169-11	445'	N 59-00 W		
TP2	4.98	12.02		7.04	
TP3			4.19	7.83	
	62-15	31'	4.8	7.2	

BS = Back Sight BM = Bench Mark
FS = Fore Sight TP = Turning Point
⊼ Instrument

Fig. 1

are entered in the field book in the manner shown in Fig. 1, with the descriptions and observations on any point being shown on the same line. The "height of instrument" is now determined from a Bench Mark (BM) or Turning Point (TP) by using the transit as a level.

The horizontal and vertical positions of all points may now be determined. The best order of observation is: rod reading for elevation, stadia distance (then restore telescope to level position by setting middle cross-hair on first rod reading), and observation of clockwise horizontal angle from back sight. When the next traverse station (s) has been set, its stadia distance, magnetic bearing, clockwise angle are observed and a turning point is set on line approximately midway between stations.

Ground elevations are generally determined to the nearest 0.1 foot and turning points and bench marks determined to the nearest 0.01 foot.

PLOTTING

Equipment for plotting comprises one semi-circular plotting protractor (see description below), two medium size triangles, one engineer's scale, drawing pencils, headed needles, eraser, plane table sheet and drawing board mounted on tripod.

All plotting is done by recorder or transitman.

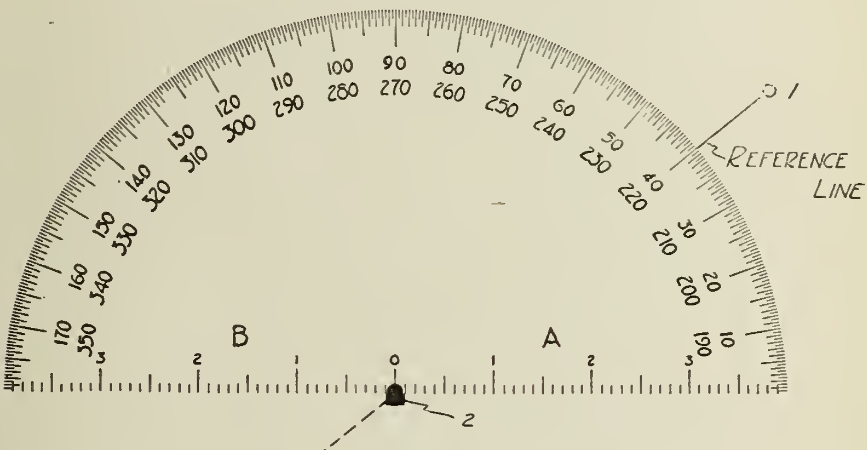


Figure 2

Plotting Protractor. The protractor is generally made from a full circle printed on Bristol board, which may be purchased from any firm handling engineering and drafting supplies. The full circles are usually eight or fourteen inches in diameter, the circumference being divided into degrees and half-degrees, the larger also into quarter-degrees.

After marking the center, the circle is cut accurately in half so that the diameter falls on one of the ten degree divisions at either end. Using the center as zero, the desired scale is laid off

along the diameter to the full length of the radius in both directions. With protractor in convex position, the scale to right of zero is designated "A" and the scale to the left is designated "B". Beginning with zero and 180 degrees at the right edge of the protractor, the degree divisions are marked around the circumference to 180 degrees and 360 degrees. At the center point, a small piece of thin metal is attached to the protractor, protruding beyond the scale edge enough to be pierced exactly on center with a hole of sufficient size to just admit a needle. The complete protractor is shown in Figure 2.

The mounted board is set up within five to fifteen feet of the transit and is approximately leveled and oriented. The traverse only is plotted by natural tangents†, but may be plotted by total latitudes and departures. With normal care and ability, these methods of traverse plotting can be performed as easily and as accurately on the plane table as in the office, and accuracy will closely approach that of any method in which traverses are not closed.

In plotting from short courses with the plotting protractor, it will be necessary to extend the reference line from the transit station through the preceding traverse station a distance greater than the radius of the protractor. The protractor is fixed in position by passing a needle through the zero point and into the map at the station where the transit is set.

To plot any given point observed by the transitman the protractor is rotated so that the graduation corresponding to the angle observed lies exactly on the reference line. This is illustrated in Figure 2 for an angle of 40 or 220 degrees. The point is then plotted at its observed distance, using the "A" scale if the angle is less than 180 degrees or the "B" scale from 180 to 360 degrees. Where the distance exceeds the scale on the protractor the line must be extended and the distance laid off with the engineer's scale.

A loose-leaf field book which will lie flat on the table when open is most convenient for recording and plotting. The plotter can record, reduce his notes and plot the points with his right hand and manipulate the protractor with his left hand. Each point is plotted and its elevation set down, with the decimal indicating the exact location.

As the work proceeds the plotter can readily observe the locations and elevations of the points plotted and notify the transitman as to their sufficiency, or as to the need of auxiliary stations. When sufficient observations have been made and the traverse readings checked, the transitman moves to the next station. The plotter

plots the next traverse station by natural tangents, checks the location with his protractor, and then moves his equipment to the next station.

The transitman can make and record all observations, and plot them, but the number of observations can often be doubled if a recorder is employed. Anyone capable of elementary drafting can be taught the essentials of recording and plotting in one day's time. A competent plotter can record, reduce and plot the observations as quickly as any transitman can accurately make them.

PREPARATION OF PLANS

The field work complete, the drainage layout may be made as shown in Figure 3, using regular highway curves and tangents for canals and other major jobs. Elevations of stations on the drainage

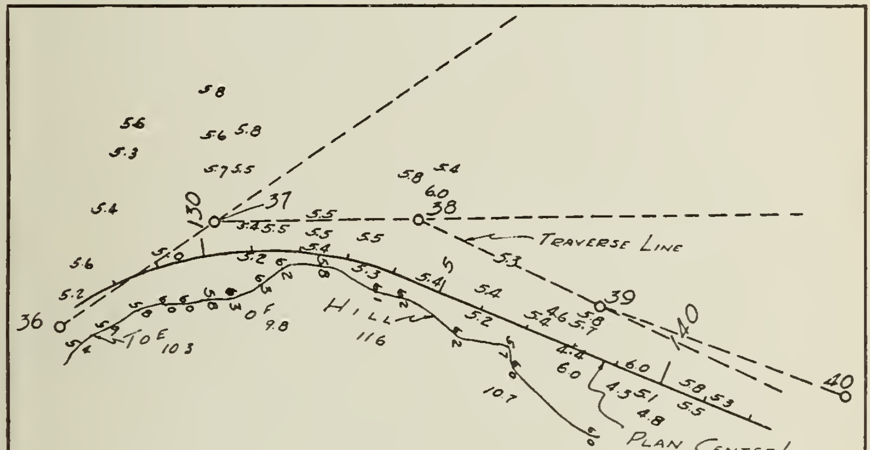


Figure 3

layout are determined by interpolation of the plotted field observations, and the profile is drawn in the regular manner. The plans are traced and complete construction estimates may be made, including earthwork, clearing and grubbing, and necessary drainage structures.

FIELD LAYOUT

The graphical layout is transferred to the ground in a manner exactly the reverse of the original procedure. The plotter, by use of the protractor, determines the angle and distance from a traverse station to the planned center line and so informs the transitman. With this information, he moves his rodman until the prescribed

conditions are met and sets a center line stake at that point (if desired, grade stakes may also be set). The same procedure is followed on tangents and curves. Where regular curves are to be run in with the transit after clearing, additional points are set in the approximate location of points of curvature, points of tangency and points of intersection.

SUMMARY

A modified method of plane table surveying has been devised and described. It retains the best points of the plane table method and, in addition, has these distinct advantages:

1. The necessary equipment is generally available or easily procurable.
2. Personnel experienced in transit operation are generally available, and plotters are easily trained.
3. This method is not entirely dependent upon favorable weather. When weather temporarily permits instrument work only, plotting can be done on return to quarters.
4. Accuracy is not limited by plotting as angles are transit measured and all courses can be computed if desired.
5. Isolation and correction of errors are easily made by study notes and complete map.
6. Speed and accuracy are increased. The transit is far more maneuverable than the alidade and a gain in efficiency of from 50 to 100 percent has been noted.

THE MEASUREMENT OF A POPULATION OF *ANOPHELES QUADRIMACULATUS* SAY

By Don E. Eyles and William W. Cox

*Presented at the joint Meeting of the National Malaria Society and the American Society of Tropical Medicine, Richmond, Va., November 12, 1942.

From the Office of Malaria Investigations, Division of Infectious Diseases, National Institute of Health

INTRODUCTION

Methods of measuring relative densities of *Anopheles* mosquitoes have been of much use in determining the efficiency of control operations. A method of making absolute measurements would, of course, be of even more theoretical and perhaps practical importance. Efforts during the summer of 1942 were directed toward applying to the measurement of populations of *Anopheles quadrimaculatus* a technique of absolute density determination which was developed by C. H. N. Jackson for use with the tsetse-fly, *Glossina morsitans* Westwood (Jackson 1932, 1936, 1939, 1940).

In a series of experiments Jackson utilized the technique of marking and recapturing insects—a technique which has been successfuly applied to the study of mosquito flight range—in estimating tsetse-fly populations. The method of Jackson is based on the following principle (Jackson, 1939, p. 238):

"A random sample of individuals is marked; at some later time a random sample is caught and examined; either the initial marking or later catching is done evenly over the area selected for study. The second catch includes a certain proportion of individuals recognized by their marks as having been caught in the first sample. Then . . . . the proportion of recaptures to total taken in the second ought to be the same as the proportion initially marked to the total population. That is the population is equal to

$$\frac{\text{total marked} \times \text{total caught when recapturing}}{\text{recaptures}}\text{".}$$

This principle, which was first applied in quantitative ecology by F. C. Lincoln in ornithological work, has been referred to as the "Lincoln Index".

The experiments conducted along this line were three in number and were carried out in the vicinity of Walnut Log, Reelfoot Lake, Tennessee. In applying the principle, which was stated above, to the study of *A. quadrimaculatus* populations the formulae and statistical methods of Jackson, which were reviewed and de-

rived at least in part by R. A. Fisher and W. L. Stevens of the Galton Laboratory, London, were used. Much of the success of the experiments here reported is due to having a method of catching and examining larger numbers of mosquitoes than other investigators have been able to handle. This technique has been described elsewhere (Eyles, 1943).

METHOD OF STUDY

Mosquitoes were caught in as nearly a random manner as possible, marked, and immediately released over the area under consideration. The first recatch was made at an interval long enough to allow intimate mixing of the marked samples with the unmarked mosquito population, and five other recatches followed at the same interval. The length of this interval was determined in manner which will be described later.

It will be noted that in the introductory principle only one recatch is referred to, but owing to the fact that the interval between marking and recapturing is of necessity not negligibly brief, allowance must be made for marked insects which die or leave the study area during the course of the experiment. This death and emigration causes the proportion of marked mosquitoes to diminish, and if environmental conditions are uniform, this rate of diminution should be constant and the proportion should die away in a regular manner, in fact in geometric progression. There is a possibility, as will be elsewhere noted (page 78), that emigration immediately after marking may be greater than later. The object of securing data from several successive recatches is to extrapolate the curve thus obtained to the day of release in order to estimate the proportion of marked mosquitoes that would have been recovered had it been possible to recatch immediately after release. In these experiments only the female population is considered, and all quantities refer to females only.

Since the number of mosquitoes caught for examination on recatch days varied, the first step in the procedure of calculating the population is to correct the number of recaptures (y) as if some constant number of mosquitoes had been released and the same number caught on each recapture day. This number was selected as 20,000 and corrections were made according to the following equation:

$$y = \frac{\text{Number marked mosquitoes recaught x 20,000 x 20,000}}{\text{No. mosq. marked x No. caught for examination}}$$

An example of this correction (employing data from the first Reelfoot Experiment) would be as follows:

Marked	Caught on Recapture Days					
30,070	19,005	23,475	18,753	14,561	13,017	16,946
	Recaptures					
	52	16	9	4	2	0

the first correction (y_1) will be $\dfrac{52 \times 20{,}000 \times 20{,}000}{30.070 \times 19{,}005}$

and the second (y_2) will be $\dfrac{16 \times 20{,}000 \times 20{,}000\text{, etc.}}{30{,}070 \times 23{,}475}$

The six corrected figures will then be

y_1	y_2	y_3	y_4	y_5	y_6
36.40	9.08	6.4	3.68	2.04	0.0

The figure which it is desired to obtain is y_0 or the number of marked mosquitoes which would have been recovered could re-catching have been carried out immediately after release. To this end, r, the average ratio of each value of y to the value preceding it must be calculated.

Mr. W. L. Stevens (Jackson 1939, p. 240) showed that when k or the number of samples is 6, the following equation gives the most accurate estimate

$$r = \sqrt{\frac{y_3+y_4+y_5+y_6}{y_1+y_2+y_3+y_4}}$$

which for the example above gives the figure, $r = 0.4670$

The equation to find y_0 is as follows

$$y_0 = \frac{y_1+y_2+y_3+y_4+y_5}{r} - (y_1+y_2+y_3+y_4)$$

which for our example gives, $y_0 = 67.78$.

It follows then from the original principle that the population (p) will be given by the equation

$$p = \frac{20{,}000 \times 20{,}000}{y_0}$$

which in our example gives a final population figure of about 5,900,000.

For calculating the error of the population estimate, Jackson (1926, 1939) gives the imposing equation for the standard error (s) of y_0

$$s^2 = \frac{y_0}{r^4}\left[(2-r)^2 r^2 A_1 r + (1-r)^4 (A_2 r^2 + \ldots + A_{k-2} r^{k-2}) + (1-2r)^2 A_{k-1} r^{k-1} + A_k r^k\right].$$

The values A_1, A_2, etc. in the above equation are correction fractions for the numbers marked and are derived by dividing the product of the number marked and the number recaptured into 20,000 x 20,000. Jackson states that this equation may be written

$$s^2 = y_0 A_1 f(r)$$

if the values of A are not very unequal. Values of f(r) can be calculated for a series of values of r once and for all from the equation

$$f(r) = \log\left\{\frac{1}{r^4}\left[(2-r)^2 r^3 + (1-r)^4 (r^2 + r^3 + r^4) + (1-2r)^2 r^5 + r^6\right]\right\}$$

In our calculations of the standard error of y_0, we used values of f(r) taken from Jackson's table for k = 6 and substituted them in the shorter equation (Jackson, 1939).

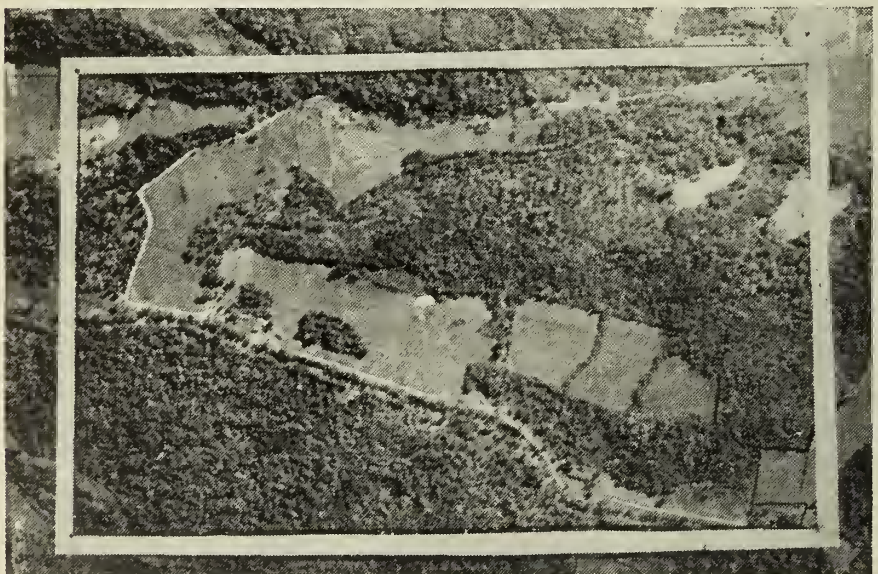


Figure 1. Aerial photograph of 400 acre experimental area at Reelfoot Lake. Margin of lake is in foreground.

EXPERIMENTS AT REELFOOT LAKE

Three experiments in applying Jackson's technique to mosquito study were conducted at Walnut Log, Reelfoot Lake. A four hundred acre tract of rectangular shape lying between the Upper Blue Basin of Reelfoot Lake and the better than 100 foot high bluff to the east was used. This area is shown in the aerial photograph (figure 1) where it is outlined by heavy white lines. As may be seen, the territory is about 75 percent wooded and consists entirely of alluvial bottomland. Besides the lake proper there are several semi-permanent basins within the area itself which are the source of some mosquitoes except in very dry seasons. Figure 2 is an outline map of the same area as the photograph, and on it are

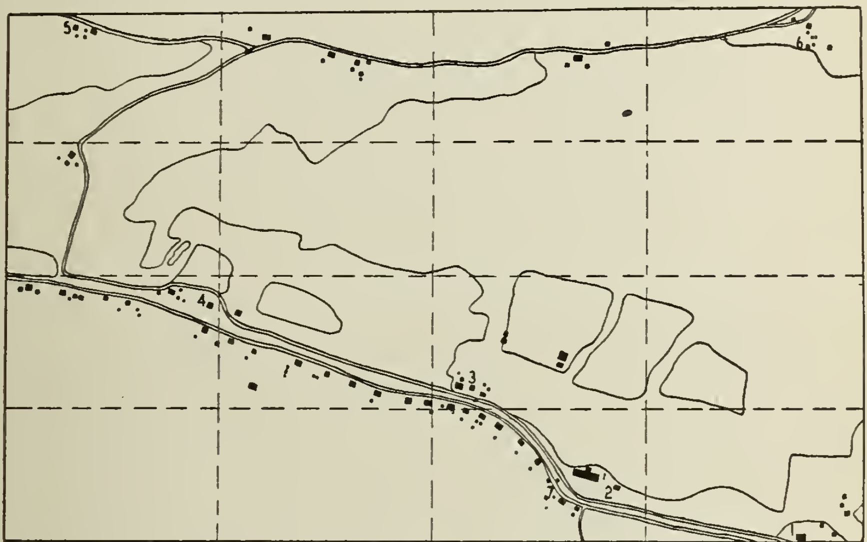


Figure 2. Diagram of 400 acre area showing all buildings and roads. Numbered buildings figure in this report.

marked all the buildings present in the area, as well as some of the physical features. Of these buildings those that figure in this report are numbered. Also shown on this map is the subdivision of the area into sixteen subareas which were used in the release of marked mosquitoes.

In the experiment area dwells a population of a little over 100 persons. Most of these show a malaria history, although at present there seems to be little malaria in the area.

All of the experiments at Reelfoot Lake were essentially similar. Collections for marking were made from buildings 2, 3, 5,

and 6 in the first and second and from buildings 2, 3, and 6 in the third experiments. Below in tabular summary are the numbers taken for marking from each in the three experiments:

	1st Expt.	2nd Expt.	3rd Expt.
Wollaston No. 2	17,180	25,000	22,912
Morton No. 3	1,960	5,400	2,087
Scott No. 5	3,800	2,620	
McQueen No. 6	7,130	9,800	5,901
	30,070	42,820	30,900

Mosquitoes were released immediately after catching and marking in shady, cool places, usually near favorable natural resting places. Mosquitoes were in each experiment caught in 16 groups—as nearly equal as possible—of approximately 2000 mosquitoes each. These sixteen groups were released, one group near the center of each of the subareas shown in figure 2. The vacuum catcher which has been previously described was used for collection and marking was with gold and aluminum bronzing dusts (Eyles, 1943). The catching, marking, and release of the 30,000 to 40,000 mosquitoes took from five to six hours.

In the first two experiments the numbers of mosquitoes released were estimated on the basis of previous counts of catcher samples; in the third experiment the mosquitoes were weighed after each catch, and although the balance used was not delicate, the latter method should be much more accurate. From the weight of a known number of mosquitoes was calculated by proportion the number in each catcher sample. This method is more fully outlined elsewhere (Eyles, 1943).

In the introductory principle, it is stated that a random sample of mosquitoes should be marked. Actually the most readily available mosquitoes, those in barns and similar diurnal resting places, must be marked as, with present technical methods, only those can be collected in sufficiently large numbers. In practice an attempt was made to collect mosquitoes for marking from barns in all parts of the area, and, after marking the mosquitoes were released in equal groups over all the area studied. This method of catching and release should, in our opinion, satisfy the requirements of a representative sample.

Recatches were also made in all four quadrants of the study area, and since recatches were considered only at three day intervals, a sufficient time was thus allowed after release for the marked

mosquitoes to redistribute themselves and become thoroughly mixed with the unmarked population. With some lapses, recatches were made daily and a consideration of the results from these daily recatches led to the choosing of the three day interval as that most likely to give a correct population estimate. From figure 3 and tables 1-3 it will be seen that data from the first few days' observations result in a concave curve when plotted logarithmically; whereas, after about the third day the decline in proportion of marked mosquitoes is constant and plotting gives a straight line. Accordingly, data were taken at three day intervals as it apparently took three days for the marked mosquitoes to become intimately mixed with the unmarked population. That is, failure of complete mixing depressed recovery proportions for the first two days.

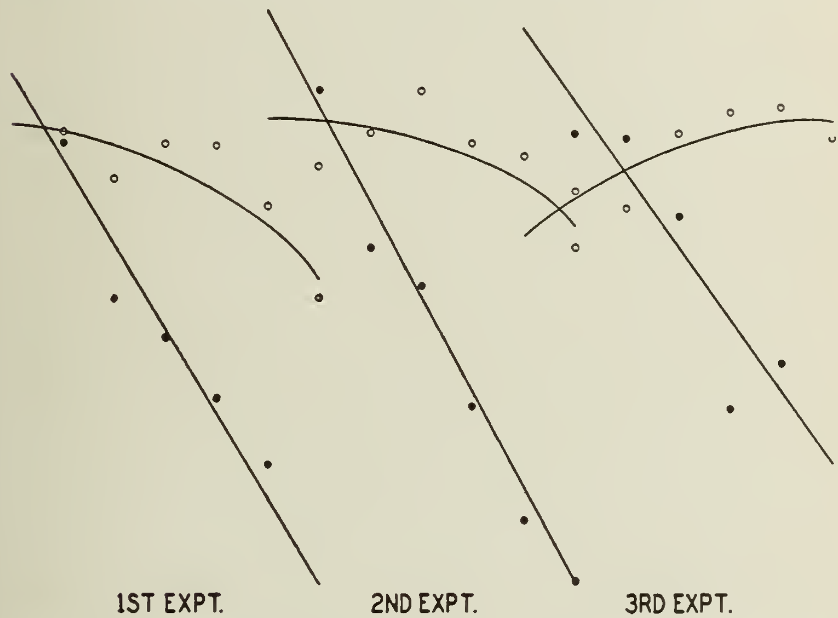


Figure 3. Graphs comparing lines obtained from plotting data taken at single and three day intervals. Data is plotted logarithmically; open circles represent data taken at one day intervals, and solid circles data taken at three day intervals.

Recatches were made with the vacuum catcher; the mosquitoes were chloroformed; and their numbers were estimated by weighing. The number of marked and unmarked mosquitoes thus killed were so small in proportion to the total population as calculated that these were not considered in the calculation of populations.

On Tables 1-3, below, are summarized the recatch figures individually from the various catching places, and at the foot of

each table is given the total recatch by days and the y-values calculated as described in the section on *Method of Study*. Only the figures in bold type (the data at three day intervals) were used in calculating the populations.

Table 4 summarizes the data for the three experiments. As may be seen, populations measured successively at two week intervals were found to be 5,900,000; 3,400,000, and 4,050,000 respectively. The standard error of these estimates is also noted on the table. Thus it was found that in the vicinity of Walnut Log, Reelfoot Lake, density of *Anopheles quadrimaculatus* ran from 8,450 to 14,750 females per acre.

POSSIBLE SOURCES OF ERROR

In respect to the above calculations, we have tried to summarize the factors which may make the calculations result in error. The population figure will, of course, be erroneous to the same degree that the original estimate of the numbers released is in error. Probably when figuring by catcher-full this error would not be over 15 to 20 percent (Eyles, 1943), but it is believed that weighing (with the catcher sealed airtight) gives a more accurate figure.

The second possible source of error is an initial excessive dispersal before the first recatch. The data show that the decline in proportion of marked mosquitoes is regular after the first recatch, but with the present technique it is impossible to determine what occurs on the first night after release. We hope to be able to obtain data to uphold or disprove this speculation through the use of more than one marking color. This initial great emigration would be likely if it proves that *A. quardrimaculatus* females have a limited beat or ambit from which they rarely escape during their life, but if dispersion is random, it is probable that no such initial dispersion occurs.

Another factor which might lead to error would be the sudden immigration (or birth within the area) of large broods of females *A. quadrimaculatus* during the recatch period. This would lower irregularly the proportion of marked mosquitoes, but dipping in previous years at Reelfoot indicates that the addition of new mosquitoes to the population is fairly regular, particularly in the late summer months.

Evidence for or against homing was sought after for positive evidence would add one more source of error. It was decided that if it was found that an abnormally high percentage of mosquitoes

TABLE 1

FIRST REELFOOT EXPERIMENT—RECATCHES

	JULY, 1942 14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	AUGUST 1
Building No. 1																			
No. caught	1390	1990	1980	1471	1944	2217	2380	613	1105	723	199	737			1327	1710	2120	2480	2660
Recoveries	11	4	0	1	0	2	1	0	1	1	0	0			0	0	0	0	1
Building No. 2																			
No. caught	2000	1960	5210	3610	5650	7060	3739	2397	3858	5470	2325	2300			1855	2835	3450	4140	2766
Recoveries	5	1	19	12	14	2	0	0	1	2	0	1			0	1	0	0	0
Building No. 3																			
No. caught	1540	2636	3550	3420	2363	3760	3170	3970	2920	4240	3762	3960			1830	2165	3560	1460	2485
Recoveries	5	5	11	13	6	6	2	0	1	2	0	3			0	0	0	0	0
Building No. 4																			
No. caught	2740			3084	3042	4330	4520	4350	3910	3100	2450	1839			1949	2800	2118	3440	2172
Recoveries	5			7	3	5	4	3	1	0	1	0			0	0	0	0	0
Building No. 5																			
No. caught	960	2070	2542	2079	2650	2460	1655	2630	3180	3880	4060	2400			2765	2040	2180	2100	2550
Recoveries	2	4	4	3	3	0	0	4	1	1	0	0			0	0	0	0	0
Building No. 6																			
No. caught	2130	1193	1980	1540	2180	2188	1247	3545	2530	4390	4180	2325			1658	2360	1600	2105	2540
Recoveries	6	4	7	5	2	1	0	2	4	1	1	0			2	0	0	0	0
Building No. 7																			
No. caught		2162	2340	1217	494	1460	1100	1235	1250	1070	734	1000			1633	1498	1016	1221	577
Recoveries		5	10	3	0	0	0	0	0	0	0	0			0	0	0	0	0
Miscellaneous																			
No. caught		700	934																
Recoveries		2	1																
TOTAL caught	10,960	12,711	19,005	16,421	18,323	23,475	17,811	18,740	18,753	22,873	17,501	14,561			13,017	15,408	16,044	16,946	15,750
TOTAL recoveries	34	25	52	44	28	16	7	9	9	7	1	4			2	1	0	0	1
y — values	82.40	26.16	36.40	34.60	19.88	9.08	5.24	6.40	6.40	4.08	0.76	3.68			2.04	0.88	0.0	0.0	0.84

TABLE 2

SECOND REELFOOT EXPERIMENT—RECATCHES

	JULY				AUGUST															
	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16*
Building No. 1																				
No. caught	1327	1710	2120	2480	2660	1860	2000	1492	980	1474	663	1128			1710	1150	1268	1393	1496	1463
Recoveries	9	7	4	7	2	5	4	0	1	0	0	0			0	0	0	0	0	0
Building No. 2																				
No. caught	1859	2835	3450	4140	2766	2295	3950	6540	3250	3540	3105	2895			3626	4515	3855	3620	1899	3875
Recoveries	2	11	29	18	10	1	14	9	2	3	5	2			0	1	1	1	0	1
Building No. 3																				
No. caught	1830	2165	3560	1460	2485	2127	2087	1640	2087	1635	2364	1450			1473	1888	2800	1870	1439	1443
Recoveries	7	10	37	8	17	6	6	3	1	2	3	1			2	2	0	0	0	0
Building No. 4																				
No. caught	1949	2800	2118	3440	2172	3155	2940	2535	2385	2390	3842	1742			2940	1874	1240	1460	1747	3141
Recoveries	3	13	8	15	7	4	3	2	6	4	3	1			0	0	0	0	0	0
Building No. 5																				
No. caught	2765	2040	2180	2100	2550	870	1532	2226	2335	2520	1856	1200			2550	2012	2610	1828	1620	2640
Recoveries	1	5	12	10	9	0	1	6	0	1	1	0			0	1	0	0	0	0
Building No. 6																				
No. caught	1658	2360	1600	2105	2540	1535	1980	2500	1531	2200	1675	1713			1994	2920	2600	2380	3380	1790
Recoveries	6	8	5	6	9	2	0	4	3	2	1	0			0	0	0	0	0	0
Building No. 7																				
No. caught	1633	1498	1016	1221	577	1495	356	273	428	2241	975	881			834	440	473	383	560	311
Recoveries	13	11	4	2	0	2	0	1	0	5	1	0			0	0	0	0	0	0
TOTAL caught	13,017	15,408	16,044	16,946	15,750	13,337	14,845	17,206	12,996	15,975	14,580	11,009			15,127	14,799	14,846	12,934	12,141	14,563
TOTAL recoveries	41	65	99	66	54	20	28	25	14	17	14	4			2	4	1	1	0	1
y — value	29.48	39.48	57.68	36.52	31.92	14.00	17.64	13.56	10.08	9.92	8.96	3.40			1.24	2.52	0.64	0.72	0.0	0.64

*A final marked mosquito was taken on August 22, the 26th day after release.

TABLE 3
THIRD REELFOOT EXPERIMENT—RECATCHES

	AUGUST 11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Building No. 1																		
No. caught	1710	1150	1268	1393	1496	1463			1650			1588			208			1474
Recoveries	4	2	3	0	2	1			0			0			0			0
Building No. 2																		
No. caught	3626	4515	3855	3620	1899	3875			2805			2580			5670			3434
Recoveries	10	5	14	24	4	16			7			2			4			0
Building No. 3																		
No. caught	1473	1888	2800	1870	1439	1443			1381			1595			2806			1777
Recoveries	0	6	7	15	11	5			5			1			1			0
Buil[illegible] No. 4																		
No [illegible]	2940	1874	1240	1460	1747	3141			1840			2730			2265			2829
[illegible]	1	3	6	4	9	10			3			0			1			0
Bu[illegible] 5																		
[illegible]	2550	2012	2610	1828	1620	2640			1736			2270			3305			1574
[illegible]	2	1	8	7	8	5			0			0			1			0
Bu[illegible] 6																		
[illegible]	1994	2920	2600	2380	3380	1790			1410			3120			2510			4351
[illegible]	6	4	1	6	11	5			0			1			0			0
Bui[illegible] 7																		
[illegible]	[illegible]	440	473	383	560	311			1020			1648			1200			2194
[illegible]	4	2	7	1	1	0			2			0			0			0
[illegible]	[illegible]	,799	14,846	12,934	12,141	14,633			11,842			15,531			17,964			17,633
[illegible]	[illegible]	23	45	47	46	42			17			4			7			0
[illegible]	[illegible]	0.12	39.24	47.08	49.12	37.06			18.60			3.32			5.04			0.0

TABLE 4

SUMMARY OF EXPERIMENTS AT REELFOOT

	Number Released	y_1	y_2	y_3	y_4	y_5	y_6	Value of R	Value of y_0	Standard error of y_0	Population	Average density per acre
1st Experiment Walnut Log, July 13, area 400 acres	30,070	36.40	9.08	6.40	3.68	2.04	0.0	0.4670	67.78	6.04	5,900,000	14,750
2nd Experiment Walnut Log, July 27,	42,800	57.68	14.00	10.08	3.40	1.24	0.72	0.4258	117.76	7.60	3,400,000	8,500
area 400 acres 3rd Experiment Walnut Log, Aug. 10, area 400 acres	30,900	39.24	37.06	18.60	3.32	5.04	0.0	0.5239	98.88	7.64	4,050,000	10,125

was recovered from barns from which they were originally caught for marking, this would constitute good evidence for homing. Actually, the resting place in which was found the greatest proportion of marked mosquitoes was a source of mosquitoes for marking, but other buildings which were not used as a source had proportions almost as high, and the building with the lowest proportion of recoveries was also a source of mosquitoes for marking. Thus it was concluded that the evidence gave no indication of homing.

SUMMARY

A method for measuring the real density of *Anopheles quadrimaculatus* Say females is presented, and the results of three efforts to apply this method in the vicinity of Reelfoot Lake, Tennessee, are given. In this area of exceptionally high mosquito density, the average number of *A. quadrimaculatus* females per acre was found to be 11,000, this being derived from three measurements in July and August. Possible sources of error in this method are pointed out.

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A METHOD FOR CATCHING, MARKING, AND REEXAMINING LARGE NUMBERS OF ANOPHELES QUADRIMACULATUS SAY

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The following technique was developed during the past two years in connection with experiments on flight range, dispersion, and related problems concerning *Anopheles quadrimaculatus*. This method provides a means of handling much larger numbers of this species of mosquito than previously described techniques.

CATCHING

For the catching of mosquitoes a vacuum cleaner with suitable modification was employed. A cleaner of the tank type using a ¼ h.p. A.C.-D.C. motor was found to be most suitable as it could be powered with a portable D.C. generator if an A.C. line was not available. At the end of the cleaner tube (a double length tube facilitated reaching inaccessible corners or high places in the resting places) a catching chamber was attached as shown in the diagram and photographs (figures 1, 2, and 3). This was constructed from two 6 3-8 inch diameter pantry cans set end to end. An intake "spout" through which the mosquitoes enter was affixed to the top of one can. In cross-section the spout was a little less than two by four inches, but the size of this can be modified for different catching conditions. At the bottom of the upper can is cut a hole 5 inches in diameter, thus leaving a narrow rim around the bottom, and to this rim is affixed by screws the top of the lower can with a similar 5 inch hole. Between these two is placed a piece of bobinet or cheesecloth and a gasket of rubber and all of the components are drawn together tightly. Thus the top can, in which the mosquitoes are caught, will fit firmly onto the lower can. At the bottom of the lower can is mounted a sink drain piece to which in turn is fastened the cleaner tube.

In operation (figures 2 and 3) mosquitoes are drawn into the intake "spout" by the rapidly moving stream of air and are brought

*Presented at the joint Meeting of the National Malaria Society and the American Society of Tropical Medicine, Richmond, Va., November 12, 1942.

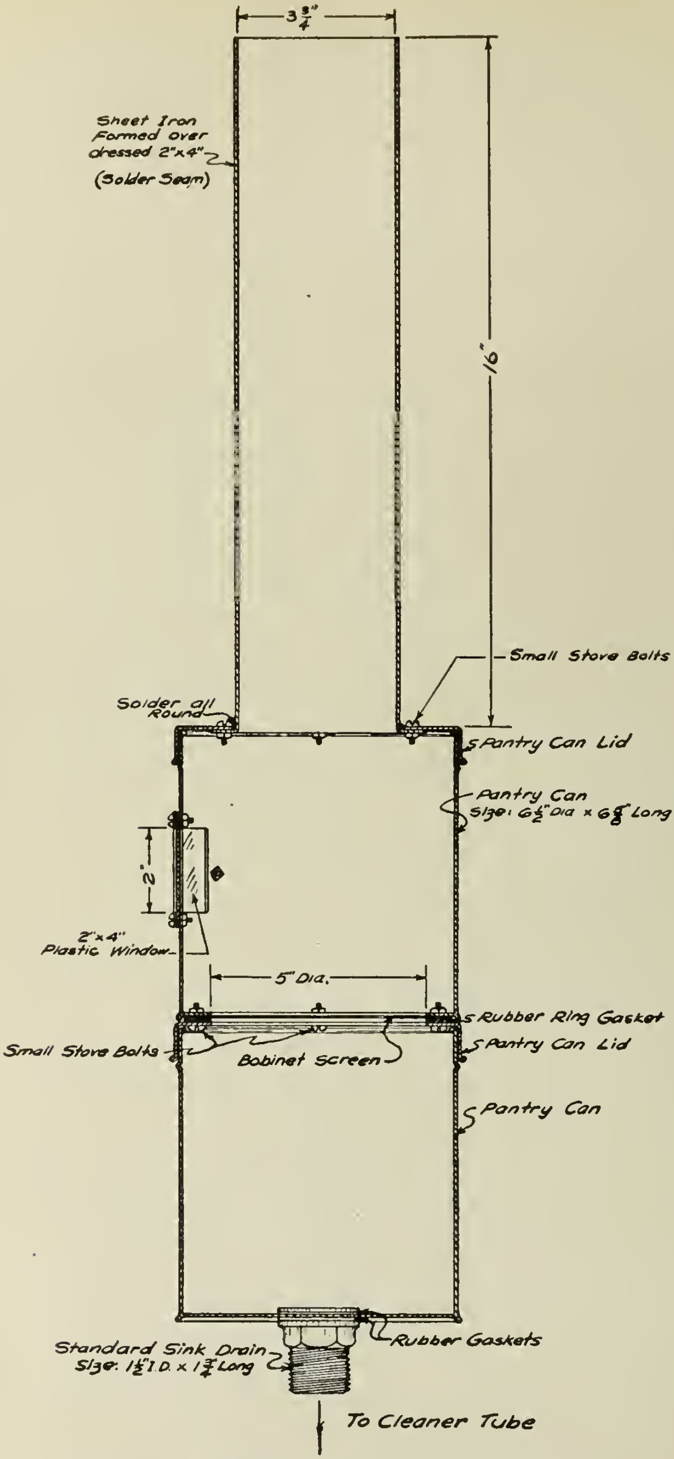

Figure 1. Schematic diagram of mosquito-catcher.

down into the catching chamber where the air movement is distributed over a much greater area. Mosquitoes caught and kept in this catcher for 15 minutes showed no greater mortality than controls which were caught by forcing wild mosquitoes to fly into an open ended cage.

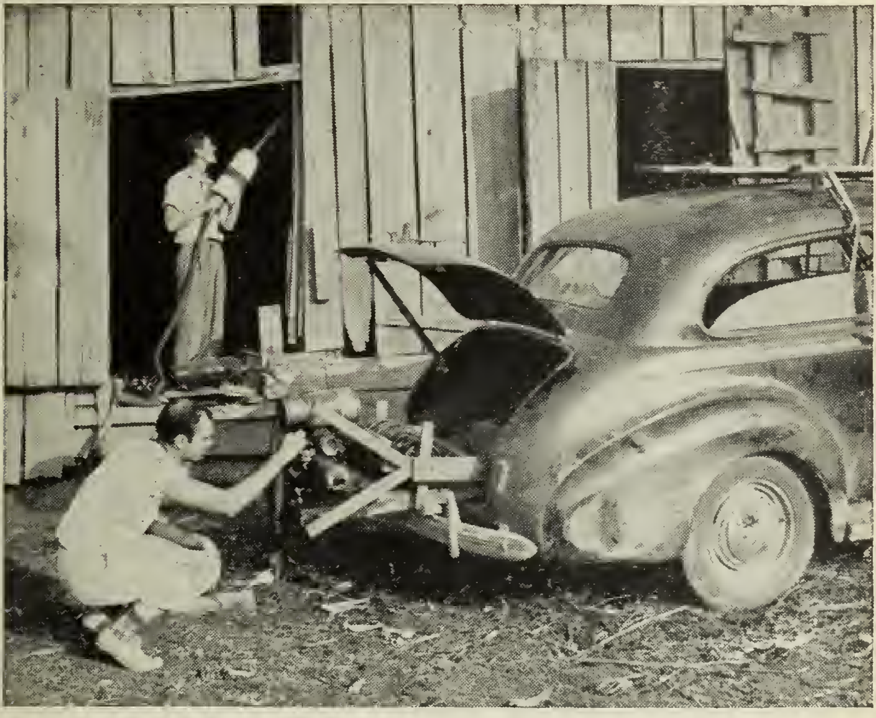

Figure 2. Photograph of catching operation showing portable generator, vacuum cleaner, and catcher.

With this apparatus 2,000 to 3,000, perhaps more, mosquitoes can be caught at one time without injury, and on one occasion in the course of six hours about 40,000 were captured, the chief limiting factor being the availability of mosquitoes. During the 1942 season over 875,000 mosquitoes were caught by this and the method described below.

Numbers of mosquitoes can be estimated from previously counted catcher samples, or can be determined by tightly closing the catching chamber at both ends and weighing it and its contents, subsequently subtracting the weight on the can alone. From this weight can be calculated the number of mosquitoes if the weight of a given number be known. In general a gram consisted of 250

to 300 mosquitoes, but this varied from resting place to resting place, the number being smaller in the resting places in which was found the greatest proportion of freshly fed females. Suitable allowance can be made for male or culicine mosquitoes accidentally caught. In estimating numbers from previously counted catcher

Figure 3. Close up photograph of catcher in operation.

samples, a consideration of the variation in these counts would indicate an error of not over 15 to 20 per cent.

For catching mosquitoes for killing, when it was immaterial that they not be harmed, a mailing tube 2 inches in diameter and 3 inches long, with a bobinet screen near the bottom, was attached by means of a rubber adaptor to the vacuum cleaner tube (Figure 4). This chamber was prepared by sawing off the mailing tube about 1½ inches from the bottom; the bobinet was then placed in position and the tube mended with adhesive plaster. The advantage of this catcher lies in the small aperture, which allows a rapidly moving stream of air to enter, and its light weight. After catching, the open end of the chamber is closed with a mailing tube cap; a plug of cotton dampened with chloroform is placed in the bottom

end and a cap also put on this end. A few minutes suffice to kill the mosquitoes and they are ready in a convenient container for later examination. Only 500 to 1,000 mosquitoes could be caught in this apparatus, but these could be caught in a matter of a few minutes. No experiments were carried out to determine the deleterious effects of this catcher, but no visible harm was done the mosquitoes.

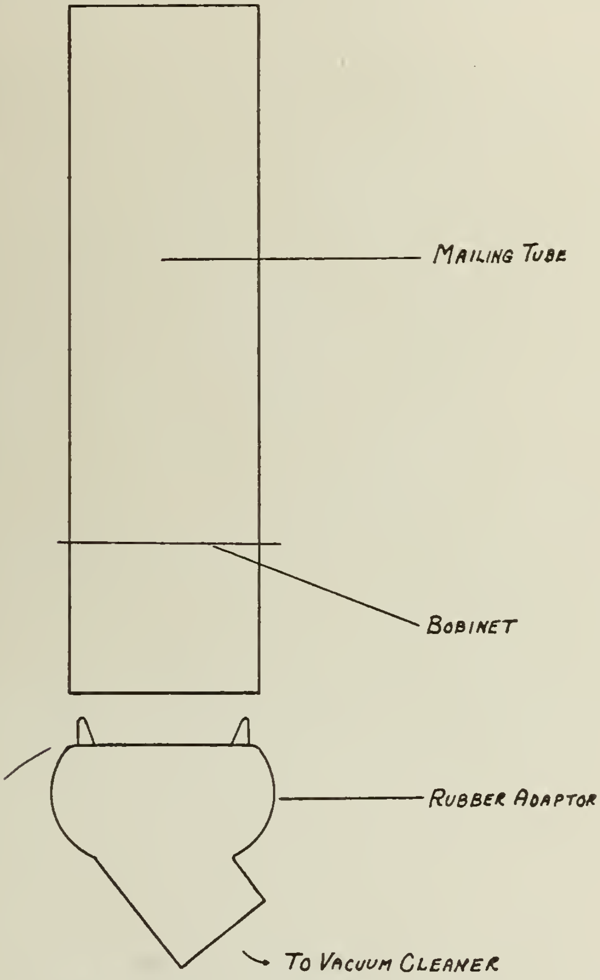

Figure 4. Schematic diagram of rapid catcher made from mailing tube.

This method is an elaboration and improvement of the technique described in an earlier report (Eyles, 1943). Griffitts and Griffitts (1931) described the use of a vacuum catcher in capturing mosquitoes in airships.

MARKING

Mosquitoes were marked with fine aluminum or gold bronzing dusts, a medium which was first described by Majid (1937). The varieties designated as striping or lining were most satisfactory (a manufacturer states that the latter contains a large percentage of particles under 25 microns in diameter). These dusts were applied to the mosquitoes, in the catching chamber previously described, by

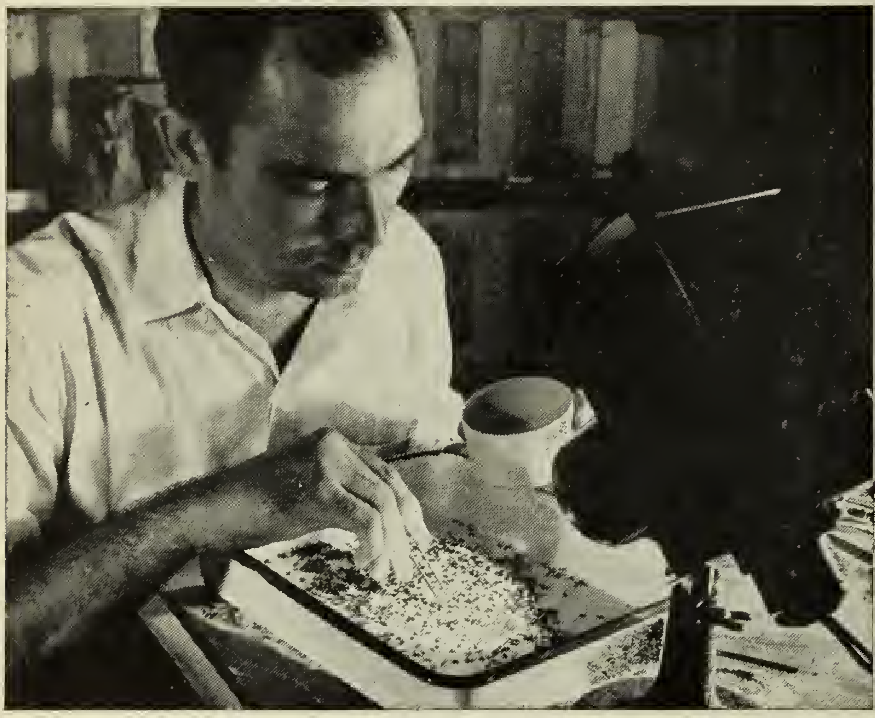

Figure 5. Photograph showing method of searching for marked mosquitoes.

means of an atomizer. An excess may be applied without harm to the mosquitoes as it appears that only a certain amount will adhere to them. Analysis by the Division of Chemistry of the National Institute of Health, U. S. Public Health Service, disclosed that a sample lot of 300 marked mosquitoes bore an average of 0.05 milligrams of aluminum per mosquito (Eyles, 1943). This may be compared with an average mosquito weight of about three to four milligrams. The natural variation in mosquito weight is many times the weight of the marking dust.

Mosquitoes after marking may be released from the catcher

cans themselves or may be transferred to larger containers for temporary storage. In the case of transfer, care must be taken not to allow the escape of marked individuals. Experiments showed that the marked mosquitoes showed no greater mortality than controls captured in the manner described in the first section of this paper. Other experiments showed that the dusts were not transferred from one mosquito to another. That the markings are durable is evidenced by the capture after 26 days of a distinctly marked individual.

REEXAMINATION

The examination of captured mosquitoes for markings is macroscopic and can be done very rapidly. I routinely examined 15,000 to 25,000 daily, and at times examined and counted as many as 3,000 in one hour. The method is merely to pour a moderate number of mosquitoes (about 200 at one time) into a white enameled pan and examine each mosquito individually but briefly under the light of an ordinary microscope lamp (figure 5). The marked mosquitoes thus located will shine brightly. Ordinarily the number of mosquitoes in a lot from one catching station was estimated by weighing, but actual counting does not slow the process down too much.

SUMMARY

A method of catching large numbers of *Anopheles quadrimaculatus* with no ill effects to the mosquitoes is described. With this apparatus, the principal factor limiting the number of mosquitoes which may be caught is their availability. A secondary apparatus is described for catching quickly mosquitoes for killing.

Attention is called to the use of metallic bronzing dusts for marking mosquitoes, and the technique of marking is described. The advantage of this marking medium is the fact that marked insects may be detected macroscopically. The technique of detection is also described.

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THE INTERSECTION LINE AS A FACTOR IN ANOPHELINE ECOLOGY

By A. D. Hess and Thos. F. Hall*

INTRODUCTION

It has long been recognized that the production of *Anopheles quadrimaculatus* is closely associated with the presence of vegetation and flotage. For this reason it was believed that population densities of *Anopheles* larvae might be correlated with the density of vegetative cover or of flotage; however, studies reported by Hinman et al (1940) in the Tennessee Valley gave no indication of such a correlation. In this report it was suggested that "the percentage of cover actually in contact with the water surface is more important than the total amount of cover". Subsequently Penfound (1941) elaborated upon this idea and presented a graph showing the theoretical relationships between larval densities, plant cover, and intersection line (termed by him "plant surface-water surface border"). During the summer of 1941 a preliminary study was made of these relationships, using lotus (*Nelumbo lutea*) as the test plant (Hess, 1941). Additional studies were carried out during the summer of 1942. The present report presents a brief summary of the data obtained.

DEFINITIONS

"Intersection line" is defined as "the line of intersection between three interfaces, water-air, water-plant, and plant-air". Thus, for a floating leaf the intersection line is the perimeter of the leaf where it intersects the water surface; for an emergent stem, it is the perimeter of the stem at the water surface; etc. Although strictly speaking it is not correct to refer to the "amount of a line", it is convenient to refer to the linear extent of the intersection line as the "amount of intersection line" as we might refer to the amount or length of a clothesline or rope.

"Intersection value" may be defined as "the number of meters of intersection line per square meter of water surface". Thus, a

*From Laboratory Services, Health and Safety Department, Tennessee Valley Authority, Wilson Dam, Alabama, November 3, 1942.

square meter of water surface containing five meters of intersection line would have an intersection value of 5. This value is used for convenience in making comparisons of different areas.

METHODS

Plots were chosen with only floating leaves of lotus and with a minimum or absence of flotage and vegetation other than lotus; thus, the intersection line within the area was limited to that produced by the floating leaves of lotus. In this way a simple situation was provided for testing the relationships between cover, intersection line, and larval densities.

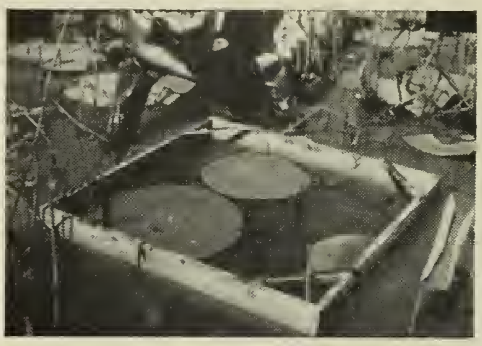

Figure 1. Sampling frame in place.

Wooden frames either one-half or one meter square and eight inches deep were used to enclose each sample area (See Figure 1). The frames floated with the sides extending several inches below the water surface, and observations indicated that the *Anopheles* larvae did not escape from the frames when disturbed.

After placing the frames in the water, the per cent cover within the enclosed area was estimated and recorded. The diameter of each floating leaf within the enclosed area was then measured and later converted to the circumference, making proper allowance for the overlapping of leaves and the intersection of leaves with the sides of the frame. The total leaf circumference in contact with the water surface was taken as the amount of intersection line within the enclosed area, and from this the intersection value was calculated.

After the leaves were measured, they were removed and the anopheline larvae within the frames were counted and recorded. This operation was facilitated by muddying the water beneath the frame.

RESULTS

During July and August of 1942 study was made of 111 plots, each one-half meter square (area one-fourth square meter). These plots were located in lotus with floating leaves only about one-half the normal size, thus making it possible to use the one-half meter quadrats. The results of these studies are summarized in the accompanying graph (Figure 2).

The relationships shown in Figure 2 agree closely with the predictions made by Professor Penfound (1941). As the number of floating leaves (cover) increased, the amount of intersection line also increased up to the point where the leaves began to overlap; then, with further increase in the number of leaves and more overlapping, the amount of intersection line decreased; finally, when the cover approached 100 per cent, the water surface was almost completely covered by the overlapping leaves, thereby greatly reducing the amount of intersection line. In individual samples where the cover of floating leaves actually reached 100 per cent, there was no longer any air-water interface, and the intersection line was therefore completely eliminated. Larval densities closely paralleled the intersection values, thus indicating a high positive correlation between the production of *Anopheles* larvae and the amount of intersection line. Consequently, the highest larval densities occurred with a medium cover, while low densities occurred with both high and low cover.

DISCUSSION

It should be pointed out that the relationships between the amount of cover and the amount of intersection line will not be the same for different types of vegetation or for the same type under different situations, especially with reference to water levels; however, the important point is the correlation between the amount of intersection line and larval densities. If the relationship of these two factors is similar in other species of vegetation to that found in lotus, then the intersection line may be, as suggested by Professor Penfound (1941), "the most important single factor in the production of anopheline larvae".

Several possible reasons for the correlation between larval densities and intersection values are apparent: (1) the intersection line may furnish larvae physical protection from their natural enemies, (2) the intersection line may furnish a microcosm for the production of epiphytic algae and other food organisms of

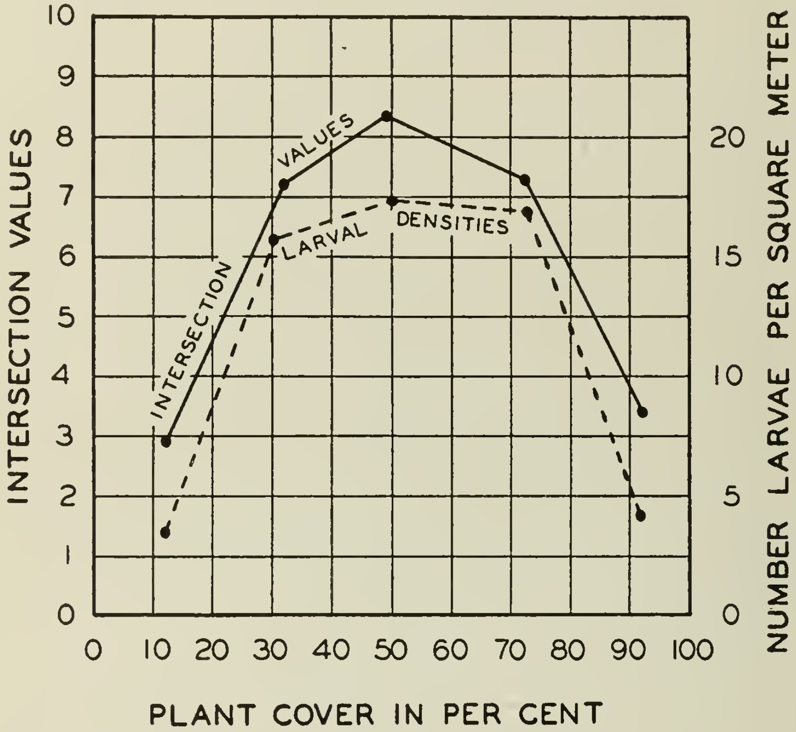

FIG. 2 INTERRELATIONSHIP OF PLANT COVER, INTERSECTION VALUES, AND LARVAL DENSITIES AS DETERMINED FROM 111 SAMPLES IN LOTUS, NELUMBO LUTEA, FROM WHEELER RESERVOIR, JULY AND AUGUST, 1942

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anopheline larvae, and (3) the intersection line may produce a more favorable situation for oviposition by the adult female mosquitoes by dividing the water surface into small cells of quiet water (Rozeboom and Belkin, 1942). It is interesting to note that these three reasons express the three fundamental requirements for the successful propagation of any species: food shelter, and facilities for reproduction.

The general assumption that densities of *Anopheles* larvae are positively correlated with the amount of intersection line clarifies a number of puzzling situations with regard to the biology and control of anopheline larvae. Among these are the following:

1. Failure to establish correlations between larval densities and plant cover (Hinman, 1940).

The relationships for floating-leaved plants are illustrated by the data on lotus. Erect, emergent vegetation will produce a high intersection value and may show high larval densities when the water level is up in the leafy portion of the plant, but will produce low intersection values and low larval densities when the water level is down around the naked portion of the stems. Submerged vegetation normally creates no intersection line and produces no anopheline larvae, but during flowering periods or low water levels, it may intersect the water surface, resulting in a high intersection value and a high production of larvae.

2. Failure to establish consistent correlations between larval densities and the amount of flotage (Hinman, 1940).

The interrelationships between amount of flotage, amount of intersection line, and density of *Anopheles* larvae should be similar to those shown for floating-leaved plans. Thus, the maximum density of larvae would be expected to occurr with moderate amounts of flotage, and, as the amount of flotage increased and the individual pieces began to overlap, the intersection value and the larval densities would be expected to decrease. General observations in the Tennessee Valley tend to confirm these relationships.

3. Variations in the effectiveness of water level fluctuation in controlling anopheline larvae in different types of vegetation.

General observations indicate that control of anopheline larvae by water level fluctuation is most effective in emergent vegetation, that it is least effective in floating vegetation, and that at times it may actually favor production in submerged vegetation. The intersection line theory offers a plausible explanation of these relationships. Thus, in emergent vegetation, such as *Saururus cernuus*, when the water level recedes from the upper leafy portions

down around the naked stems, the amount of intersection line is greatly reduced, and consequently the production of larvae is also greatly reduced. In floating vegetation, the amount of intersection line is not affected by changing water levels, and larval control by water level fluctuation is therefore ineffective. In submerged vegetation, receding water levels may cause the plants to break the water surface and create a high intersection value which will result in an increase rather than a decrease in larval production.

SUMMARY

"Intersection line" is defined as "the line of intersection between three interfaces, water-air, water-plant, and plant-air". "Intersection value" is defined as "the number of meters of intersection line per square meter of water surface".

One hundred and eleven samples collected in floating leaves of lotus, *Nelumbo lutea,* indicated a high positive correlation between the intersection value and the population density of *Anopheles quadrimaculatus* larvae.

The intersection line theory offers an explanation for a number of puzzling situations with regard to the biology and control of anopheline larvae.

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